DOCUMENT RESUME

ED 125 851 SE 019 195

TITLE	Meeting of Experts on Environmental Aspects of Engineering Education and Training (Paris, June 17-21, 1974). Final Report.
INSTITUTION	United Nations Educational, Scientific, and Cultural Organization, Paris (France).
PUB DATE	Oct 74
NOTE	112p.; Marginal legibility throughout
AVAILABLE FROM	UNESCO, 7, Place de Fontenoy, 75700 Paris, France
EDRS PRICE	MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	Conference Reports; Developing Nations; *Engineering Education; *Engineers; *Environmental Education; *Guidelines; *International Programs; Manpower Development; Planning; *Training
IDENTIFIERS	Environmental Engineers; *UNESCO

ABSTRACT

This publication presents the final report of the Meeting of Experts on Environmental Aspects of Engineering Education and Training held in Paris, June 17-21, 1974. Convened by UNESCO in cooperation with the United Nations Environmental Programme (UNEP), this meeting was part of a series of activities that UNEP is undertaking or assisting, aimed at supporting and encouraging the training of experts in various environmental fields. The objective of the meeting was to provide UNESCO and UNEP with guidelines on future programs that should be undertaken to assist member states in strengthening the environmental education of engineers. The meeting reviewed the need and means for the inclusion of environmental concepts into the education of all engineers, the strengthening of educational programs aimed at producing engineering graduates for work in environmental areas, and the inclusion of environmental components in continuing education programs for presently practicing engineers. The institutional structures that are needed to meet these objectives were also discussed. The meeting gave special attention to the conditions in developing countries and to the environmental consequences of development. Conclusions and recommendations formulated by the meeting are included. (BT)

united nations environmental programme

final report

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I. BACKGROUND

INTRODUCTION

The meeting was organized by Unesco within the framework of its programme of promoting the reform and development of engineering education, and with the financial assistance from the United Nations Environment Programme (UNEP). It was part of a series of activities that UNEP is undertaking or assisting, aimed at supporting and encouraging the training of experts in various environmental fields, and the training of personnel in the techniques of incorporating environmental considerations into development planning. The meeting gave special attention to the conditions in developing countries and to the environmental consequences of development. Other United Nations agencies as well as interested non-governmental organizations sent observers at Unesco's invitation. The list of participants is given in Annex II.

The objective of the meeting was to provide Unesco and UNEP with guidelines on future programmes that should be undertaken to assist Member States in appropriately strengthening the environmental education of engineers.

The meeting was opened in Unesco House in Paris, 17 June 1974, and reviewed the need and means for the inclusion of environmental concepts into the education of all engineers, the strengthening of educational programmes aimed at producing engineering graduates for work in environmental areas, and the inclusion of environmental components in continuing education programmes for presently practising engineers. The institutional structures that are needed to meet these objectives were also discussed. The agenda for the meeting is given in Annex I.

OPENING OF THE MEETING

The meeting was opened by the Assistant Director-General for Science, Mr. J. M. Harrison, who, on behalf of the Director-General welcomed the participants and observers (Annex IV gives the text of this address; as well as those of other speakers at the opening of the meeting).

ELECTION OF CHAIRMAN, VICE-CHAIRMEN AND RAPPORTEUR

The meeting elected the following officers to constitute its Bureau:

Chairman:	Mr. R. G. Norman
Vice-Chairman:	Professor A. El-Erian
Rapporteur:	Professor A. Ramachandran

II. SUMMARY OF DISCUSSIONS

The working sessions of the meeting began with the presentation and discussion of the background papers prepared in advance by the four Unesco consultants. These documents are included in Annex V of this report. Frequent references to these papers were made throughout the course of the meeting, and there was general agreement amongst the participants that they constituted an invaluable source of information on the subjects of discussion.

Deliberations then centred on item 6 (a) of the agenda, the environmental concerns that have prompted the reappraisal of world priorities and have led to such actions in the field of engineering education as the holding of this meeting.

Item 6 (a) of the agenda: Environmental concerns and prospects

Global problems

One of the submitted papers provided discussion on global environmental problems, including energy consumption, production and disposal of noxious compounds, and effects on the world's water and air. The underground disposal of dangerous substances was singled out as a particularly hazardous policy, bearing in mind possible needs of future generations to exploit water or other resources in the earth's crust.

Throughout the meeting there was repeated mention of situations where familiarity with other sciences was essential for full understanding of the impact of engineering works, and the examples quoted highlighted the importance of such fields as social sciences, ecology, soil sciences, marine

biology, meteorology, and human biology. Concern was expressed not only that the engineering profession was not sufficiently in contact with those in specialized scientific fields, but that the latter were themselves often reluctant to co-operate with engineers and to attempt to understand the broader implications of the use of technology and of economic and social development. Increased understanding between different professions is imperative, as it increases motivation to tackle in a multidisciplinary manner complex problems of importance to society. The rôle of professional and learned societies was mentioned as being especially important in this context.

History of social consequences of technology

Furthermore, the discussion concerned the history of technology, and its relation to development and environmental changes. Many changes were quoted, ranging from lead poisoning and deforestation in Roman Empire times, to the construction of steam turbines and large modern industrial projects. Problems of scale and complexity were perceived as very important, especially in relation to infrastructure and environment, and some participants suggested that, in the trend to gigantic works, economies of scale in production were often not real, bearing in mind all the secondary effects of the undertaking.

Thus some development projects may turn out to be counter-productive, when viewed in a regional perspective. However, some participants insisted that this may often be due to the fact that the engineers responsible were given exceedingly restrictive terms of reference, the fundamental decisions having been made at a different level or, in some instances, even in another country. There was general agreement on the utility of learning from the past, by carefully studying actual cases, and using these in engineering education and disseminating them, particularly through the journals of engineering associations.

Development and environmental problems

It was repeatedly pointed out that environmental concerns differed widely around the world, and that they were intimately related to the process of development of both the economy and the society. In many regions and countries, the major problem was survival in hostile environments, such that development implies primarily a modification of the environment. The examples quoted included tropical forest areas with impoverished soils and the desert regions of Africa and Asia. Betterment of the populations in these areas could be brought about by resource development and by the application of technology, bearing in mind its whole range of short- and long-term environmental consequences.

On the other hand, in many industrialized countries the major environmental concerns were seen as those of pollution, urban crowding, dereliction, and ecological damage. In many of these countries there may not be a real problem of lack of resources, rather a question of choice of social priorities.

Urban settlements, natural resources, the oceans and the environment

In the discussion four areas of critical importance were identified, areas that participants considered should be given greater emphasis in the strengthening of environmental components of engineering studies.

In the first of these, human settlements, engineering works play a major rôle but to date engineers have usually only been interested and involved on separate parts of the problem such as streets and highways, water supply, or building structures. The rapid growth of urban populations, poor housing, urban migration and dereliction of existing cities are such that in coming decades urban problems will become critical in many countries, of all levels of development and massive engineering works will certainly be undertaken. Engineering curricula do not usually give any attention to urban development issues, and yet a large proportion of all engineers do work that has environmental impact on life in urban areas. Human settlements in rural areas are another aspect of this problem where engineers have an important rôle to play.

The development of natural resources is a key to the improvement of the livelihood of those in developing countries, especially mineral and forest resources, agriculture and water resources. Far too often, engineering education in these countries is too academic in approach and does not adequately prepare graduates for their future rôles, especially that of planning or controlling projects for the exploitation of resources. Together with economic and legal factors, environmental aspects are of capital importance, notably in large-scale mining operations.

The oceans of the world represent huge potential sources of food and mineral resources, and engineering activity in and around the seas is rising rapidly. Only in very few instances, however, have engineering education institutions responded to this new area, as engineering education has traditionally tended to stop short at the water's edge or at the end of the sewage outfall pipe. Offshore technology and undersea mining are obviously important in themselves, but the environmental impact on the oceans and enclosed seas of all engineering works needs to be given greater attention in the initial and continuing education of engineers.

The effects on the environment of large-scale industrial complexes was discussed in detail and examples in Japan and France were mentioned. Problems concerning population movements, land use, transitory effects during the construction period, traffic, pollution, microclimates, disaster risks and ecological and cultural consequences were mentioned. This seemed an area of importance to education in all engineering disciplines and where case study approaches could effectively be used.

Item 6 (b) of the agenda: Engineering manpower requirements

Engineering manpower categories

There was general agreement that much work will be necessary in defining categories of personnel required in environmental fields and, while there will logically be great differences between conditions and needs in different countries, it was thought useful to carry out comprehensive manpower studies in a number of countries as soon as possible. Those aspects of a qualitative nature were suggested as being more important than attempts to predict numbers of engineers required in the future, as experience has shown that such calculations often prove to be inaccurate.

Several speakers stressed the continuing importance of environmental health engineers, working in such areas as water supply, sewage treatment and vector control, but it was emphasized that environmental engineering cannot be restricted to health questions, but should be concerned with the general problem of providing man with as favourable an environment as possible. Thus education to give understanding of the ways in which social and environmental equilibrium may be preserved and restored is essential for engineering students in all disciplines.

Environmental engineers and environmental managers

There was considerable discussion on whether environmental concerns would result in an increased demand for engineers. One view was that qualitative questions were most important, and that in many countries the demands would be for better educated or better retrained engineers, rather than for more of them. On the other hand, some participants felt that increased numbers of engineers may prove necessary in some specializations, such as chemical engineering and civil engineering. It was pointed out that engineering works affecting the environment on a large scale such as sewage treatment or river control structures, often required many different engineering specializations for their design and construction, where perhaps few engineers could be classed as specialized environmental engineers.

On the other hand, a clear need for environmental management engineers or environmental managers was seen, men who would have the breadth of view and experience to be able to plan and administer environmental control services in cities or larger regions. There was some difference of opinion as to whether special undergraduate courses should be used for training environmental managers, whether only post-graduate courses should be used and in the latter case whether engineers and non-engineers could or should be trained in the same programmes. The training of "environmental integrators" was also suggested, persons having the capacity to direct the multidisciplinary teams required for environmental work.

Manpower needs in engineering education and training

Many participants identified teacher training and retraining as a high priority, especially in the context of curricula reform to include environmental concepts into all courses, and that of creating, within educational institutions, linkages between departments that have tended to remain isolated and illusorily self-sufficient. It was thought that this should best be undertaken at institution and national levels but, where groups of countries in one region have comparable environmental and development problems, an international approach may be desirable.

Manpower needs regarding technicians

Although discussion was mainly focused on rôles and needs for engineers, the needs for engineering technicians of various types and levels were also mentioned. Technicians in environmental protection and monitoring functions were obviously going to be required in increasing numbers, but the environmental awareness of technicians in industry also needs to be promoted by education and in-service training.

Item 6 (c) of the agenda: Options for engineering education

Discussion on item 6 (c), took place mostly on the basis of the following scheme:

Engineering education: programmes methods and areas

Programmes

1.1 Introductory courses on environmental quality for all undergraduate engineering students.

1.2 Programmes centred around society, technology and development as part of the social sciences and humanities context of undergraduate engineering programmes.

1.3 Projects in undergraduate programmes emphasizing multidisciplinary and systems approaches.

1.4 Courses, workshops and seminars, developed indigenously in each country in areas of local relevance with, if necessary, support or expertise from abroad.

1.5 Workshops on environmental standards, instrumentation and techniques for engineers in government and industry.

1.6 Post-graduate programmes in environmental management, based on "systems" and "resource" approaches.

1.7 Workshops for engineering educators to develop environmental insights in their respective disciplines, for use in their instructional programmes.

1.8 Short courses for in-service engineers using case studies and other means, to develop environmental appreciations, skills on environmental problems, etc.

1.9 Regional workshops to emphasize utilization of local materials, recycling, low energy use for optimizing habitats and services.

Methods

2.1 Development of teaching materials, educational technology, visual aids, etc., for use in engineering institutions.
2.2 Creation or strengthening of laboratories and field investigation facilities of institutions dealing with environmental areas.
2.3 Encouragement of excursions, trips to major projects for in-situ studies of environmental assessments.
2.4 Compilation of files information and referral services in environmental areas, in co-operation with UNISIST and other information services.
2.5 Preparation of case studies of completed projects dealing with technical, economic and environmental appraisal of such projects.
2.6 Development of analytical methods for handling environmental data, especially with computers.
2.7 Promotion of communication skills and development of ability to deal with the public and policy-makers on matters concerning environment and technology.
2.8 Promotion of historical and socio-economic aspects of technology and its applications in relation to the environment.

Activities

3.1 Examination of necessity for setting up institutes or centres of environmental studies in universities to promote multidisciplinary teaching and research.
3.2 Undertaking of pilot studies on ways and means to promote multidisciplinary teaching in environmental areas.
3.3 Encouragement of professional societies to organize seminars, exhibitions and confrontations dealing with environment on national, regional and international levels.
3.4 Examination of alternatives to technologies having an environmental impact and appropriate to countries concerned.

Continuing education of engineers

The priority that should be given to increasing the environmental awareness of engineers who have already graduated was frequently stressed, on the grounds that for the next 20 or 30 years it is they who will be dominating the engineering activity. Many will be working in environmental management, with or without any formal training for such rôle, and many more will be in areas where their work will have direct impact on the environment. Continuing education must increase their competence but, even more importantly, should give them an awareness of environmental problems and issues, such that they can foresee effects, rather than defensively react after the secondary effects of their works become apparent. The professional engineering societies and employers were seen as playing a key rôle in continuing education, and it was suggested that in many countries the universities and engineering schools should be more positive in their attitudes to continuing education.

It was also mentioned that there would be many benefits if professionals from different fields participated jointly in continuing education programmes, as this would add to the value of the training and would promote subsequent co-operation.

Issues regarding the curriculum and methods of engineering education

There was unanimity as to the need to develop ways of using case studies in engineering education, comparable to the way that these are sometimes used in other professions such as medicine and management. They would be most useful if they could be multidisciplinary in nature and this would bring benefits to the teachers as well as to the students. There are many difficulties in developing such methodology, but participants believed that high priority should be given to the encouragement of institutions to experiment with case study methods of introducing environmental aspects into engineering education at all levels.

On the other hand, there appeared to be divided opinions as to whether general lecture courses on environmental problems were an effective means, because of the danger that student motivation to learn could be low if these courses were not seen to be closely related to their interests, or were not well taught. It was recognized, however, that in some instances special courses on such topics as "environmental protection" might be necessary and successful in disciplines such as chemical and civil engineering, but in this instance the course should be tailored to the particular curriculum.

Co-operation among international organizations in the field of engineering education

There was general agreement that more effective international and regional co-operation was needed to encourage improvement of the education of engineers and other specialists with whom they would be working during their careers. Thus, as well as improving co-operation between groupings of engineers, links should be strengthened between them and other professional national and international levels. It was suggested that the Man and the Biosphere (MAB) programme could be used as a mechanism for this co-operation, and also that the International Council of Scientific Unions (ICSU) and its constituent bodies, notably the Scientific Committee on Problems of the Environment (SCOPE), should participate. In addition, closer co-operation would need to be established with the World Health Organization (WHO), the World Meteorological

Organization (WMO), the United Nations Industrial Development Organization (UNIDO), and other related organizations.

The need for close co-operation with the United Nations Environment Programme (UNEP) was stressed, both with regard to financial support and to ensure that activities undertaken by Unesco are complementary to other related activities receiving UNEP support. Co-operation with the United Nations Development Programme (UNDP) and the International Bank for Reconstruction and Development (IBRD) was also mentioned, especially the possibility of placing more stress on the environment in projects being financed by these bodies.

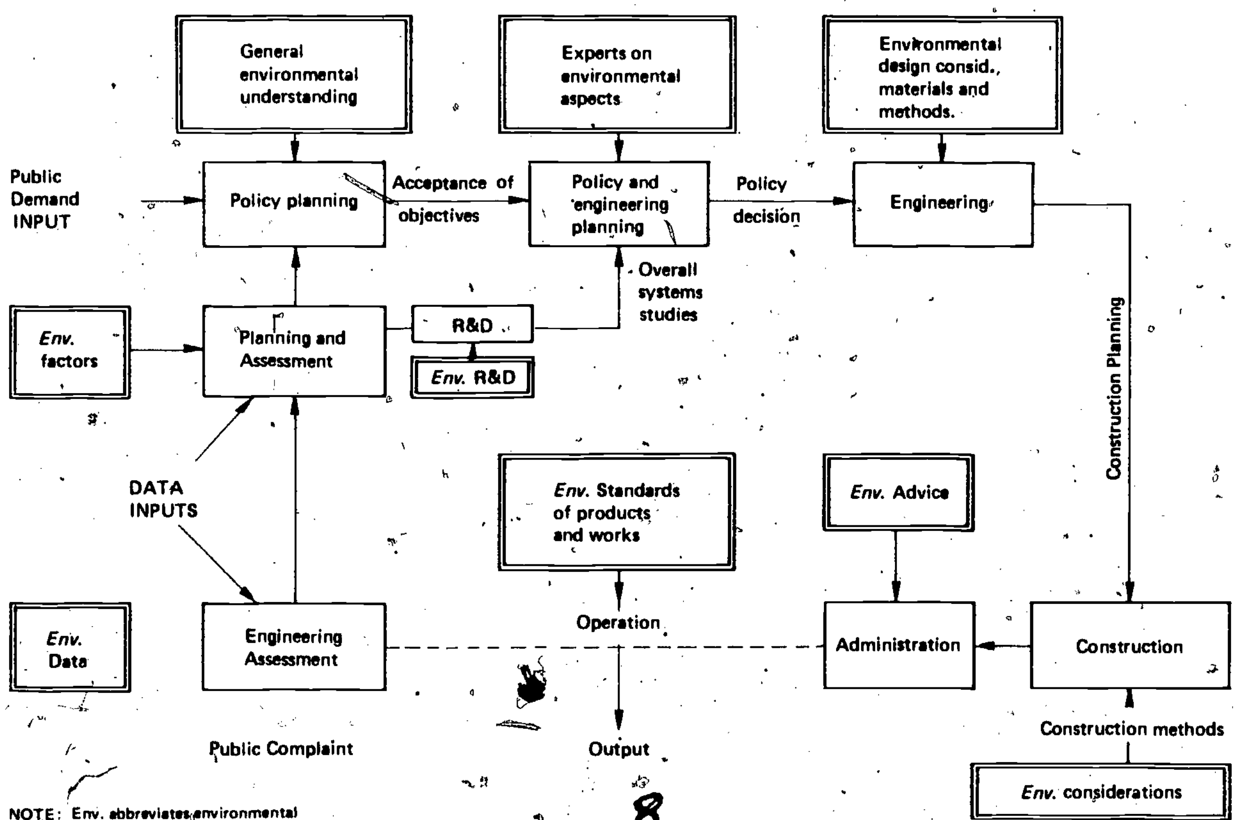
The work of the World Federation of Engineering Organizations (WFEO) Committee on Education and Training was mentioned, also that of the regional groups concerned with engineering education, including the European Federation of National Engineering Societies (FEANI), the European Society for Engineering Education (ESEE), the Union Panamericana de Asociaciones de Ingenieros (UPADI), the Federation of Arab Engineers (FAE), the Committee on Engineering Education in Middle Africa (CEEMA), the Association for Engineering Education in South and Central Asia (ASEESCA) and the Association for Engineering Education in Southeast Asia (AEESEA).

The meetings, journals and newsletters of these regional associations were seen as a mechanism for dissemination of information on environmental aspects of engineering education, but there was general agreement that the publication and wide distribution of an international newsletter, perhaps entitled "Engineering Education and the Environment", would be an effective means of giving world-wide publicity to problems, innovations, and sources of information. The possibility of the newsletter being published by Unesco in co-operation with WFEO was suggested, and it was agreed that the matter needed further study.

There was general agreement that in any event all engineering courses should now have a fabric of environmental content woven into them, especially those dealing with design, construction, operation and economics. It was remarked that today many well presented courses do include societal and environmental considerations.

Reference was made to the opportunity of integrating social science and environmental aspects of engineering education. The work of the Social Sciences Sector of Unesco was described by the Secretariat and the Unesco Seminar on the Rôle of Social Sciences and Humanities in Engineering Education, held in Bucharest (September 1972), was mentioned. It appears that the growth of environmental concern adds further justification to the need for social sciences and humanistic disciplines as an integral part of engineering curricula, by relating these non-technical disciplines in an operational way to environmental studies and problems. Participants suggested that new approaches along these lines should be encouraged.

Fig. 1. SIMPLE MODEL OF ENVIRONMENTAL IMPACT RELATIONSHIPS



NOTE: Env. abbreviates environmental

The rôle of systems analysis

The use of modern multidisciplinary systems analysis in environmental problems was regarded as most important, for this would enable the engineer to obtain a proper broad view of the impact of engineering works and of the factors to be taken into account in their design. One participant proposed a simple model of these relationships, which is shown in Figure 1.

Meterological considerations

Especially with regard to urban settlements and large industrial complexes, meteorological considerations are of substantial importance in the engineering design and in the operation of industries, and yet meteorology is rarely included in engineering curricula. It was thought that, perhaps in the form of case studies, meteorological concepts should be considered.

Environmental implications of energy supply systems

The relationship between energy and the environment was discussed at some length, from the point of view of varied environmental implications of mining fossil fuels, oil exploitation and processing, and also regarding the environmental problems associated with power generating stations. This seemed to be a sector of industry where engineering has a very positive rôle to play, but where an optimal balance in terms of development objectives has to be sought through interdisciplinary co-operation at all levels of decision and implementation.

Item 7 of the agenda: Co-operative international programmes

There was extensive discussion of ways in which UNEP and Unesco and other organizations could promote better education of engineers in environmental topics. It was recognized that WHO, WMO and the International Atomic Energy Agency (IAEA), would continue to promote the training of specialists in their respective areas, notably through regional centres such as the Inter-regional Sanitary Engineering Centre in Rabat, Morocco, and by the development of teaching materials and that these programmes would need continued support. The in-service training work of UNIDO was also very important and the possibilities for their increased use to promote environmental concepts was mentioned, as was the possibility of linking them with Unesco programmes in continuing education.

Priority areas for action were identified as continuing education, teaching training, preparation and dissemination of teaching material, information and publicity, and institution building. It was considered that, bearing in mind the very large number of engineering schools around the world, it would be preferable to concentrate any pilot projects on a limited number of existing institutions, chosen so that maximum results are likely to be achieved and having the capacity to publicize work in their regions.

An integrated group of projects was finally recommended by the meeting as being those where Unesco and UNEP could most frutifully direct their efforts. These projects are presented in pages No. 12 to 16 of this report under the framework of a draft proposal for a "World Programme on Environmental Aspects of Engineering Education and Training".

III. CONCLUSIONS AND RECOMMENDATIONS

The Meeting of Experts on Environmental Aspects of Engineering Education and Training, convened by Unesco in co-operation with the United Nations Environmental Programme, carried out its tasks from 17 to 21 June 1974.

The meeting felt that the problems brought to their consideration were urgent and of world-wide concern. In particular, the meeting had the conviction that members of the engineering profession have a clear responsibility to their countries and to the world at large in the safeguard and improvement of the quality of the human environment. This responsibility stems from the rôle of the engineer as the creator of new technology and as one of the decision-makers on the conditions under which this technology is used for the ultimate progress of destruction of human society.

In this sense, the Secretariat considered it opportune to recall the Stockholm recommendation that the attention of governments be drawn to the need to adapt the training for the members of all professions involved in environmental planning, particularly the training of "professional people who act directly upon the environment such as engineers, architects, town and physical planners". The recommendation explains further that "it would be necessary to introduce into the existing curricula of training for these professions a set of general notions with advanced training in the environmental management techniques associated with each of the professions concerned"*.

After a thorough discussion of the substantive items of the agenda, which permitted a broad exchange of ideas, among individual participants, representatives of other agencies of the United Nations system, representatives of non-governmental organizations, Unesco consultants and members of the Secretariat, the meeting was able to formulate its recommendations as follows:

Overall recommendations

1. That in all its programmes concerning the education and training of engineers and

* This recommendation is contained in paragraph 113 of the report of the Secretary-General of the United Nations Conference on the Human Environment on subject area IV: Educational, Informational, Social and Cultural Aspects of Environmental Problems.

technicians, Unesco should stress the importance of environmental concerns and concepts, on a local and global scale.

2. That Unesco should continue and expand its co-operation with UNEP in this work and should work closely with other international organizations and agencies, especially the World Health Organization (WHO), the United Nations Industrial Development Organization (UNIDO), the World Meteorological Organization (WMO), the International Labour Organisation (ILO), the Food and Agriculture Organization (FAO), the United Nations Development Programme (UNDP), and the International Bank for Reconstruction and Development (IBRD). Furthermore, wherever appropriate, non-governmental organizations such as the International Council of Scientific Unions (ICSU), and the World Federation of Engineering Organizations (WFEO), should be associated with these activities, and the regional bodies such as the European Federation of National Engineering Societies (FEANI), Pan-American Federation of Engineering Societies (UPADI), the Federation of Arab Engineers (FAE), the Committee on Engineering Education in Middle Africa (CEEMA), the Association for Engineering Education in Southeast Asia (ASEESEA), the Association for Engineering Education in South and Central Asia (ASEESCA), that are concerned with engineering education should be encouraged to include environmentally-oriented activities in their programmes.

3. That such co-operative activities be envisaged as a world-wide effort to stimulate reflection, experimentation and innovation in engineering education and training, and that the sharing of information and experience be a priority aspect of this work.

4. That in contributing to technological development engineers give increasing importance to the constraints of environmental quality thus developing a better understanding, not only of the interaction of development with the environment, but also of the rôle of environmental scientists. Conversely it seems desirable to provide opportunities for environmental scientists (both social and natural) to understand the engineering problem of guiding technological development to achieve social purposes within a whole complex of constraints.

5. That at a regional or sub-regional level, countries having similar ecological and developmental conditions should be encouraged to develop links between their engineering schools and professional societies, so as to develop co-operation in teaching and research in environmental fields related to engineering.

6. That at a national level, those engaged in engineering education should reappraise the orientation and objectives of teaching and research, taking into account local development needs and environmental conditions, and in consultation with those in other disciplines, to study the necessity for more environmental studies to be included in the curricula.

Furthermore, the meeting stressed the importance of the analysis of manpower needs and of career profiles for engineers in the light of environmental issues, and maintained that these needs will vary widely according to the social, economic and ecological situation in each country. In developing countries the emphasis may be placed on balanced development of natural resources, water supplies and sewerage, urban settlements, and rural development. In the more industrialized countries pollution and transportation aspects may need to be given greater emphasis. In this context, it is recommended:

7. That studies be carried out in every country to determine the environmental areas which are currently most important, with regard to engineering practice, and to outline the qualification characteristics of the engineering personnel whose work will influence these areas.

8. That basic training of all engineers shall include study of environmental and ecological principles, so that they are able to foresee, not simply react, to environmental consequences of their work. Whenever necessary, training on environmental matters of a special nature must be included in specific branches of engineering.

Manpower

Engineers have played a major rôle in the technological development of the present society and should continue to do so. An appropriate consideration of man as a part of the environment must be fundamental in the work of all engineers. Insights in basic and environmental principles must therefore be a part of the training at all levels.

Education effort aimed at improving environmental understanding among engineers must usefully be directed towards education in the following three phases, set out in order of priority:

(i) in-career education and training of practising engineers should be promoted based upon short-term courses and examination of case studies involving the use of multidisciplinary principles;

(ii) undergraduate education of all engineers shall include environmental and ecological principles and studies aimed at a general understanding of environmental problems;

(iii) engineers intending to specialize on environmental impact should pursue suitably arranged post-graduate higher degree courses.

It is recommended:

9. That studies be carried out on the needs and categories of specialist engineers in environmental fields, as well as needs for engineers able to assume rôles in environmental management.

10. That the training of practising engineers be considered as a priority matter. Effective short-term courses using modern techniques should preferably be used.

Institutions

11. That Unesco, when planning and implementing international technical co-operation programmes in the field of environmental education of engineers, fully recognizes that higher education

systems are characterized by their great diversity throughout the world in the same way that are socio-economic policies and development objectives. Thus, while no universal moulds are desirable, it is of the greatest usefulness and urgency that governments and institutions involved in a process of innovative reform be provided with a set of alternatives which could serve to document technically their decisions based to a large extent on overall national policy considerations.

12. That an emphasis commensurate with the government's overall environmental policy be placed in environmental quality objectives when the reform of higher education, and particularly engineering education, is contemplated by different countries.

13. That in the study of alternatives for the reform of engineering education and training, governments and higher education establishments give due consideration to the possible need for reorganization of institutional structures (e.g. the creation of inter-departmental institutes or laboratories oriented towards environmental quality problems; the establishment of new organizational structures that facilitate the co-operation of such areas as engineering, architecture, planning law, economics and social sciences in teaching and research on the environment).

Curricula

14. That in the regular revision of curricula, attention should be given to the strengthening of environmental concepts, through the inclusion of additional courses or by integration into existing programmes. It is necessary to introduce, into the tuition programmes of all levels, from primary to university, some elementary concentration not only on the imperative need of environmental protection, but similarly on the complex nature and interdependence of all phenomena involved.

15. After being informed by the Secretariat of the forthcoming publication in English and French of "Social Sciences and Humanities in Engineering Education" (based on the results of the Bucharest Seminar held in late 1972)*, the meeting recommends that Unesco endeavour to give it the widest possible diffusion among engineering educators and engineering education institutions, possibly together with the report of this meeting, since the meeting feels that the problems of environmental aspects of the education for engineers can only be approached effectively by a consideration of both socio-humanistic and scientific-technological elements in the process of education of these professionals.

That as a possible means of strengthening social science components of engineering education, experimentation be encouraged in the use of case studies on past and present impact of technology on man and his environment.

16. That in the graduate tuition programmes of all specialization disciplines relative to environmental protection, elements be introduced to enable mutual exchange of information and mutual understanding among the various professional groups.

In order to understand environmental situations, engineers should learn to work in team situations, in collaboration with professionals of other disciplines, such as economists, managers, lawyers, sociologists and political scientists.

17. The engineer of tomorrow must have, in the range of social and human sciences, a knowledge sufficient to enable application of his technical skill in the solution of important social problems, and thus to contribute practically to social progress.

It is therefore recommended that:

(a) In all disciplines and specializations of engineering education, the subject "Environmental Protection" be introduced, closely relating the problems of environmental protection to the specific scope of problems in the engineering specialization.

(b) Whenever necessary, training on environmental problems of a special nature must be included in specific branches of engineering, e.g. chemical engineering (combustion and air pollution); electrical engineering (siting of power stations).

(c) All engineers be trained to approach complex situations requiring multidisciplinary knowledge and the use of systems analysis methodology.

IV. DRAFT PROPOSAL FOR A WORLD PROGRAMME ON ENVIRONMENTAL ASPECTS OF ENGINEERING EDUCATION AND TRAINING

Objectives of the programme

To ensure that environmental considerations are taken into account in development projects and other engineering works, especially with reference to economy of energy and other resources; development and dissemination of environmentally sound technologies; the prevention of pollution and the promotion of healthy urban and rural environment on a global scale.

The programme is based on the conclusions of the Meeting of Experts on Environmental Aspects of the Education and Training of Engineers held in June 1974.

Implementation of the programme

Under the programme various projects will be executed in the years 1975, 1976 and 1977. These projects will be aimed at the development of teaching aids and teaching methods for the introduction of environmental concepts in engineering education, by:

* Unesco Seminar on the Social Sciences and Humanities Content of Engineering Education (Bucharest, Romania, 5-8 September 1972).

exchange of information;
reform of engineering curricula;
workshops for engineering professors and other educators;
development of new educational methodology and resources;
post-graduate programmes, especially in developing countries;
pilot projects;
other activities as recommended by the expert meeting.

Unesco will formulate details of the individual projects in close co-operation with the countries and with intergovernmental and non-governmental international organizations concerned.

A. INTERNATIONAL AND REGIONAL COMMUNICATION

(i) Development of sub-regional networks of institutions engaged in the environmental education of all engineering students

Background and objectives

The purpose of the project will be the development of a global network of interinstitutional linkages in the field of environmental education of engineers.

Unesco, through its different technical co-operation activities, has established close relations with engineering education institutions in more than 50 countries. Some of these institutions are now engaged in or are considering the development of new curricula and methods of engineering education to reflect national environmental concerns.

Description

Under this project which would cover Africa, Asia, Arab States, Europe and Latin America, Unesco would provide:

(a) a substantial number of sub-regional travel grants for engineering educators working in the environmental area in order to promote exchanges and co-operation between institutions in countries having similar environmental conditions;

(b) a number of fellowships for the training of already qualified engineering educators wishing to specialize in the teaching of environmental subjects, through post-graduate interdisciplinary studies, or through new studies outside the field of engineering, in basic areas of environmental quality management such as:
policy and planning;
legislation;
ecology;
economics;

(c) a number of fellowships for the training abroad of young engineering teachers in particular environmental control technologies related to their own branch of engineering;

(d) opportunities for exchange of fellows in (b) and (c) through the methods proposed in (a), thus maintaining an international flow and sharing of new knowledge and of eventual educational innovations resulting from the work of teachers trained under the project.

Work plan

Fifty travel grants should be provided each year in 1976, 1977 and 1978, for the exchange of teachers in the five sub-regions mentioned;
ninety man-years of fellowships would be awarded to engineering professors from institutions in each sub-region.

(ii) International newsletter

Background

A need exists for the dissemination on an international scale of information likely to stimulate engineering education institutions around the world to adapt their teaching and research programmes to environmental concerns. Innovations need to be publicized and environmental information disseminated to the world community of engineering educators, practising engineers, and professional societies.

Objective

The objective of the newsletter is to provide a vehicle for the exchange of experience and information that will stimulate the reform and development of engineering education in accordance with environmental realities. The newsletter would disseminate information on activities undertaken under this programme, together with other relevant information, and would be a source of material for the regional and national engineering journals. It would also include information on availability of courses, educational materials, and act as a catalyst for exchange of experience.

Work plan

Unesco would arrange for the publication of a quarterly newsletter "Engineering Education and the Environment" directly or in co-operation with the Committee on Engineering Education and Training of the World Federation of Engineering Organizations. It would be issued initially in English, French and Spanish, at an estimated cost of $15,000 per annum.

B. EDUCATIONAL RESOURCES PROJECT

In order that engineers be prepared to consider the environmental significance of their projects, whether in the public or private sectors, it is necessary that their education be reformed to include environmental concerns explicitly. In both formal and continuing engineering education, materials and techniques need to be developed

that will integrate environmental concerns into traditional engineering judgements.

A project to develop these materials should be undertaken by Unesco.

Examples of the types of materials that should be developed are:

1. Monographs on the theme "Engineering, Development and the Environment", that would provide an historical perspective on the rôle of engineers in contributing to the social purposes of technological development, and on the consequences to society and the environment, of engineered technological changes.

2. Case studies, including relevant data and comprehensive post-audits, of engineering projects, such as dams, highways, industrial complexes, river basin management, urban development, resource exploitation, large-scale agricultural projects, etc. Such studies should include social and environmental consequences, as well as engineering effectiveness.

3. Classroom teaching materials that would be useful in many engineering science and design subjects for modifying conventional subject material to include the environmental factors as well as the traditional parameters.

Examples include: (1) chemical process or machinery design, where all energy and materials consumed, produced or wasted are included in the overall project assessment; (2) siting of projects, where the total impact on society must be included; (3) mining, where costs of environmental protection and spoil disposal must be included in project cost studies; and (4) manufacturing processes, where worker health and safety are important components of design.

4. Engineering study projects that lend themselves to the multidisciplinary analysis so essential to the achievement of environmental compatibility. Such projects should be designed to involve students and faculty from a wide variety of disciplines and professions. Examples of such projects include new processes, manufacturing plants, community developments, etc.

5. Teaching aids ranging from compilation of appropriate library material, to the development of teaching materials exploiting modern technology, films and film strips, computerized instruction.

6. Studies of new institutional arrangements and structures in engineering education, aimed at strengthening environmental and social content of training programmes.

The above materials will assist in the execution of the other projects recommended by the meeting.

Implementation

Unesco, in co-operation with UNEP and other international organizations as may be appropriate, should undertake a project for the preparation of the monographs, case studies, classroom teaching materials, study projects and teaching aids described above.

Unesco's staff should be supplemented by consultants and the task force drawn from various fields of engineering education and practice, including environmental specialists. Because both physical and social sciences are involved in engineering education, experts from these fields should be utilized.

Unesco may consider sub-contracting portions of the project to engineering and/or educational institutions that have the necessary capabilities, and the potential for recruiting the appropriate experts.

The meeting recommends that an initial investment of 20 man-years of expert services be committed to the project.

C. PROMOTION OF EDUCATIONAL FLEXIBILITY

Pilot and demonstration programmes for multidisciplinary environmental education at engineering schools, including the use of systems approaches

Background

The growing concern for the state of the human environment has an increasing influence on the nature of the engineer's responsibilities. There is a strong interdependency between the work performed by engineers and the state of the natural environment, which is determined by many tightly interwoven factors. The single disciplinary approach is no longer satisfactory, but little is yet known on how the required multidisciplinary methods can be applied in practice. The complicated problems in this field can best be managed with the aid of the systems concept.

While these needs are present in virtually all fields of engineering activities it is considered that the most urgent needs are for the strengthening in engineering education of aspects that relate to:

human settlements;
natural resources;
marine environments and resources;
industrial complexes.

In order to achieve such innovations, some institutions may have to change their structure.

Objectives of the project

The objectives of the project are to develop methodologies for multidisciplinary training of engineers in environmentally important fields, and to develop methodologies for teaching the application of systems concepts to environmental problems. These methods will be tested in pilot and demonstration programmes undertaken in engineering institutions of various regions of the world. The programmes will stress the strengthening of critical areas that have hitherto been inadequately covered in engineering studies, namely urban and rural development, natural resource conservations, marine resources and the impact of large industrial developments. The results of these studies and the progress of the pilot programmes would be widely disseminated

through the newsletter, through Unesco channels and through the engineering education bodies being assisted by Unesco, to stimulate changes in attitudes and institutions.

Summarized description of the project

A small task force of experts in multidisciplinary environmental teaching programmes and in human communication techniques will be charged with drafting a technical paper on methods and techniques of multidisciplinary environmental education. For this aim the task force will meet several times and visit institutes where such multidisciplinary programmes are being conducted.

Work plan

A second small task force of experts in systems analysis applied to environmental problems will be charged with drafting a technical paper on the use of systems concepts in dealing with environmental problems in engineering education.

The technical papers of both task forces will include case studies and will be reviewed by one panel of experts.

Five institutions of which three will be in developing and two in industrialized countries will be selected for the pilot and demonstration programmes, selected from the fields of human settlements, natural resources, ocean resources, and industrial complexes.

These programmes will be located at engineering institutions where there can be developed appropriate institutional structures for co-operation with other higher education units, including social and political sciences, medicine, natural sciences and law. Consultants would assist in developing and conducting each pilot and demonstration programme.

D. CONTINUING EDUCATION FOR PRACTISING ENGINEERS AND ENGINEERING TEACHERS

Background

This part of the programme will be co-ordinated with work being done by UNIDO, WHO and the Unesco Working Group on the Continuing Education of Engineers. Most of the world's practising engineers have been educated at a time when the interactions between engineering works and the environment were less considered by society than is now the case. Irrespective of the training programmes being developed with the environment in mind for the present generation of students the need is even more urgent for increasing the environmental awareness of practising engineers.

This is especially true for those engaged in educating engineers. They not only want a better appreciation of recent environmental factors in engineering practice, but they also need to know how to reflect these effectively in their teaching.

(i) Workshops for engineering professors to strengthen the environmental aspects of their teaching

Objectives of the project

To explore and demonstrate how engineering educators can develop their ability to include environmental content and insights in their teaching, and to collaborate with specialists in other disciplines in their teaching and research.

Summarized description of the project

Institutions in various countries will be selected for the project. At each institution a workshop for engineering professors will be held, each dealing with the environmental aspects of one of the disciplines: civil engineering, electrical engineering, urban planning, mechanical engineering, chemical engineering, mining and metallurgical engineering. At each institution consultants or the services of a sub-contracting institute would be provided for periods depending on the needs for each case, and specialists in other disciplines would participate. For each workshop, 25 fellowships would be provided to engineering educators from developing countries.

Each workshop, which will be prepared and conducted in close liaison with national environmental authorities and interested international agencies, will give an opportunity to the participating educators to discuss teaching methods and to use relevant visual aids. Furthermore, eminent experts in the environmental field will discuss latest developments. Case material on environmental aspects of engineering projects will be collected for the workshop and made available in a form useful for engineering teaching. After each event a report will be drafted and submitted to Unesco, and this and the case studies will be widely disseminated.

(ii) Workshops and seminars for practising engineers (In co-ordinating the proposed activities, special attention will be paid to the responsibilities of other agencies in this field.)

Objectives

To develop in practising engineers attitudes that will help them better carry out work having environmental consequences.

Work plan

The workshops will be carried out on a regional or sub-regional basis whenever appropriate, as national pilot projects. The subject areas will be selected in consultation with governments, professional engineering societies, and the regional associations for engineering education. For each workshop a team of national and, if necessary, international experts will be formed

to survey the needs of the prospective participants and their employing organizations, draft study programme and organize the seminar. Where appropriate successive seminars may be organized in several countries of a region.

So as to have significant impact, a number of such seminars will be organized in each year of the Programme, with the topic, host institutions and timing being chosen to conform to local environmental concerns.

(iii) Roving seminars

Background and objectives

It had been recognized that there is a need to inform engineers, practising and those engaged in teaching, of the environmental impact of their activities. This seems to be true of all countries and is especially true of the less developed countries where the dangers and long-term effects of all types of pollution do not at this time seem especially serious, or at least less immediately important than other constraints.

It was agreed that a very useful function could be performed by a small group of experts leading a seminar or workshop in each of several centres. In regions where engineers are relatively few these centres could be in neighbouring countries, but is recognized that even in such countries a particularly large country would benefit from the seminar being given in more than one centre.

Description

The team of experts would, wherever possible, include at least one local engineer who has concern for the environmental impact of industry, agriculture, urban concentrations and public services.

The seminars would be arranged through engineering schools and national engineering organizations as well as national agencies in the field of economic and social planning and environmental protection. One major purpose would be to draw public attention to environmental dangers and a second to inform engineering teachers of the dangers and effects of certain practices, which might not as yet be well recognized.

The seminars need be of a few days duration only, to keep down costs but also to enable busy participants, especially senior ones, to attend. The discussions would be based on carefully prepared material and areas would be singled out which are of local importance.

Work plan

The peripatetic team need not be large and perhaps could consist of two experts and an assistant, who would be complemented by the addition of a local engineer. Such a team could visit four centres in two weeks, which might include four separate countries in some regions, and less in others.

This method of imparting serious and useful information by means of lectures, case studies, discussion, and supply of bibliographies would seem to have strong advantages over and certainly complement other ways of imparting an appreciation of sensitivity of our environment to human activity.

ANNEX I

AGENDA

1. Opening of the meeting
2. Election of the Chairman, Vice-Chairman and Rapporteur
3. Introductory statements
4. Review of environmental programmes of Unesco
5. Presentation of background papers
6. Discussion
   (a) Environmental concerns and prospects
   (b) Engineering manpower requirements
   (c) Options for engineering education
7. Co-operative international programmes
8. Adoption of conclusions and report
9. Closure

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LISTE DES PARTICIPANTS, CONSULTANTS ET OBSERVATEURS

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Annex III

RULES OF PROCEDURE

(Established in accordance with the "Regulations for the general classification of the various categories of meetings convened by Unesco", as adopted by the General Conference at its fourteenth session, 14 C/Resolution 23.)

I. PARTICIPATION

Rule 1 - Chief participants

The chief participants shall be experts selected and invited by the Director-General of the United Nations Educational, Scientific and Cultural Organization (Unesco). They shall serve in a private capacity.

Rule 2 - Representatives and observers

Representatives of the United Nations and organizations of the United Nations system and other intergovernmental organizations which have concluded mutual representative agreements with Unesco and observers of international organizations invited by the Director-General may take part in the meeting, without the right to vote, and subject to Rule 7. 3.

II. ORGANIZATION OF THE MEETING

Rule 3 - Terms of reference

The purpose of the meeting is to submit to the Organization suggestions or advice on the matters figuring on its agenda.

Rule 4 - Elections

The meeting shall elect a Chairman, one or more Vice-Chairmen and a Rapporteur.

III. CONDUCT OF BUSINESS

Rule 5 - Duties of the Chairman

The Chairman shall open and close each session of the meeting. He shall direct the discussions, ensure observance of these Rules and accord or withdraw the right to speak. He shall rule on points of order and, subject to the present Rules shall control proceedings and the maintenance of order. He may ascertain the sense of the meeting and shall, if necessary, put questions to the vote. The Chairman shall not vote.

Rule 6 - Acting Chairman

If the Chairman is absent or unable to attend, he shall be replaced by the Vice-Chairman who, acting in this capacity, shall have the same powers and duties as the Chairman.

Rule 7 - Order and time-limit of speeches

7. 1 The Chairman shall call upon speakers in the order in which they signify their wish to speak.

For the convenience of the discussions, the Chairman may limit the time allowed to each speaker.

The consent of the Chairman must be obtained beforehand whenever a representative or an observer wishes to make a verbal communication.

Rule 8 - Working languages

English and French are the working languages of the meeting. Interpretation and documents will be provided in these two languages.

Rule 9 - Voting

9.1 The Chairman of the meeting shall summarize the general import of the discussions. If one or more of the participants referred to in Rule 1 are not in agreement with the conclusions, their views and the grounds therefore may, at their request, be summarized in the final report of the meeting.

9.2 Decisions requiring a vote shall be adopted by a simple majority of the participants referred to in Rule 1 who are present and voting.

9.3 For the purpose of the present Rules, the expression "participants" referred to in Rule 1 who are present and voting, shall mean those casting an affirmative or negative vote. Participants abstaining from voting shall be considered as non-voters.

9.4 When an amendment to a proposal is moved, the amendment shall be voted on first. When several amendments to a proposal are moved, the meeting shall first vote on the amendment deemed by the presiding officer to be the furthest removed in substance from the original proposal, and then on the amendment next furthest removed therefrom and so on, until all the amendments have been put to the vote.

9.5 A motion is considered an amendment to a proposal if it merely adds to, deletes from or revises part of that proposal.

Rule 10 - Report of the meeting

The conclusions reached by the meeting shall be embodied in a report which shall be transmitted to the Director-General of Unesco.

IV. SECRETARIAT OF THE MEETING

Rule 11 - Secretariat

The Secretariat of the meeting shall be provided by Unesco officials and consultants appointed for that purpose by the Director-General of the Organization.

Rule 12 - Duties of the Secretariat

The Secretariat shall perform all the work necessary for the smooth functioning of the meeting.

Rule 13 - Statements by the Secretariat

The Secretariat may at any time, make to the meeting either oral or written statements concerning any question under discussion.

Annex IV

OPENING ADDRESS BY MR. J. M. HARRISON ASSISTANT DIRECTOR-GENERAL FOR SCIENCE

Ladies and Gentlemen,

It is with great pleasure that I am able to welcome you on behalf of the Director-General. It is our wish that you will have an interesting and productive meeting and a pleasant stay in Paris. We have attempted to provide the facilities and made arrangements requisite to the fulfilment of these wishes. If, however, we have overlooked anything, please let us know so that we can do whatever is necessary to facilitate your activities.

Unesco, as many of you are aware, has been over the years and presently is involved in a large number of activities that can be described by the three critical words in our name: educational, scientific, cultural. These have included a great many environmental considerations. It does not require a very thorough examination of the world's environmental problems and their solutions (achieved and potential) to realize that all three of the areas delineated in our name must be embraced. Cultural factors frequently dictate the manner in which environment is used or misused - scientific advances have frequently been the basis of technological applications that have changed the environment - but usually it is science and engineering that also hold the keys to repairing damage previously done and preventing future damage; and in all cases it is education of the engineers, as well as the architects, urban planners, ecologists and others directly involved in the environmental management process that must prepare the people who can undertake the required works. One of your tasks here is to study the relevant educational needs of young engineers being moulded for their careers and the needs of older practitioners whose formal education may have been completed in years past when, admittedly, environmental concerns did not receive the present due degree of attention.

The United Nations Environment Programme that was established following the Stockholm Conference of 1972 has recognized such needs and has entrusted Unesco to assist in studying the problems and working toward their solutions. In addition to contributing to the financing of this meeting, UNEP has, to date, agreed to support two other environmental projects in the field of Engineering Education. One is for holding an Asian Regional Workshop on Environmental Training of Practising Civil Engineers. The objective of this project is to demonstrate the possibility of environmental training, on a regional or national basis, of Civil Engineers in key positions, where they are involved in the planning and execution of major works, or concerned with regional and urban development.

The second is for Environmental Training of Engineers in Institutions in Developing Countries. This project will create pilot programmes of study in two institutions that have received or are receiving assistance from UNDP. The objectives are to show that traditionally organized engineering schools can, without great marginal costs, introduce a coherent and successful programme of basic environmental studies. In Unesco's future projects, included the two just mentioned, the final selection of the content, level, and mode of presentation will be guided by the results of your deliberations and recommendations here this week.

In addition to these Engineering Education oriented projects that pertain to the environment, Unesco has been, and is, involved in numerous other activities that relate directly or indirectly to the environment, especially:

the Man and the Biosphere Programme (MAB) which is an intergovernmental and interdisciplinary programme of research, emphasizing an ecological approach to study of the interrelationship between man and the environment, and to problems relating to regional use and conservation of the resources of the biosphere;

the International Hydrological Programme to provide a scientific framework for the general development of hydrological activities to include hydrological cycles, assessment of water resources throughout the world, the influence of man's activities on the water cycle, to promote the exchange of information, to promote education and training in hydrology and to assist Member States in the organization and development of their national hydrological activities;

Marine Sciences studies and research to promote regional and national capabilities in managing the coastal environment and support the transfer of information on marine resources and their management.

Also of importance is the work done on Earth

Science project, Solar Energy and many other technological and scientific areas.

In January 1974 we hosted, here at Unesco House, an experts meeting on Environmental Engineering. Copies of the report of that meeting have been distributed to you and should be of value to you in ascertaining some of the directions engineering work is going and thus may suggest to you the education and training needed to provide professionals to carry out the work.

In the past, consideration has surely been given to environmental factors in the education of engineers and their subsequent works. These range from the obvious, as in the activities of civil and sanitary engineers whose engineering works have solved basic environmental problems. Less obvious perhaps are, for example, consideration for effects of impounded waters from the construction of dams; routing of highways to avoid disturbance of wild life refuges and natural beauty spots; and of course structural and architectural design of buildings to provide comfortable living and working space while preserving the aesthetic appeal of the surrounding environment.

Chemical, electrical and mechanical engineers too have learned to be concerned about the environment in siting plants and designing them for minimization of smoke and other polluants, waste heat utilization and reduction of noise. The list could go on, and it must be admitted that in the past, the environmental concerns were frequently a reaction to external pressures from the community, or a by-product of overriding technical and economic factors.

The present situation regarding the training of engineers to participate in the solution of environmental problems still seems to stand as a rather complex one.

On the one hand some educators and employers of engineers advocate the establishment of post-graduate programmes in environmental engineering, usually following exposure to basic environmental studies within the traditional branches of engineering at the undergraduate level.

On the other hand there are tendencies towards the creation of undergraduate degree programmes in environmental engineering from the beginning.

Although it seems clear that there should be a basic environmental component in all types of engineering and technological education, the above mentioned problems appear important for Unesco's future programmes and I hope that the meeting will be able to provide us with illuminating thinking in this respect.

The time has now come, however, for the engineer to be imbued, during his training, with the importance of the environment as an integral element in all of his design, operating and management decisions throughout his career.

We thus look to you, through this meeting, to provide us with guidance on what action should be taken by Unesco, UNEP, and other organizations, as well as by our Member States, to face up to this new situation where environmental factors are becoming so important in the application of science and technology. You may wish to make specific recommendations about curricula, you may wish to propose new institutional structures, you may wish to suggest areas where regional and international co-operative action is required.

I am pleased to note the representation of our sister United Nations organization as well as you who represent other international organizations concerned with education, engineering architecture, ecology, etc., all of which and other fields are of importance to the deliberations in this particular meeting.

I wish you successful and productive working sessions, and I look forward to your conclusions and recommendations.

SUMMARY OF THE ADDRESS OF THE DIRECTOR OF THE DEPARTMENT OF ENVIRONMENTAL SCIENCES AND NATIONAL RESOURCES RESEARCH

The Director of the Department of Environmental Sciences and Natural Resources Research, Dr. M. Batisse, reviewed the overall Unesco programmes related to the environment. He stressed that Unesco had been interested in environmental matters since its earliest days, as shown by its promoting the creation of the International Union of the Conservation of Nature (IUCN) and its now completed Major Project on Scientific Research on Arid Zones. He then described continuing areas of activity such as hydrology, mineral resources, oceanography, and more recently the interdisciplinary programmes entitled "Man and the Biosphere" (MAB). He stressed the limitations imposed by the Organization's budget, such that it was not possible for it to finance major research programmes, but rather to play a rôle of co-ordination and stimulation of international co-operative activities. In this regard, he welcomed the availability of support from UNEP for projects involving substantial financial expenditure, such as regional training centres in ecological fields. Mr. Batisse concluded by explaining that education must be a major part of many environmental programmes, including the training of specialists such as engineers, architects, urban planners and other professionals such as economists, and underlined the need for education for public understanding of environmental issues.

ADDRESS BY DR. A. MANOS, REPRESENTATIVE OF THE EXECUTIVE DIRECTOR OF THE UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP)

Ladies and Gentlemen,

It is a privilege to be here today and to bring you greetings from Maurice F. Strong, the Executive Director of the United Nations Environment Programme.

This is the first joint activity between Unesco and UNEP at which our Secretariat is being represented. It deals with one of the subject matters to which the Stockholm Conference on the Human Environment and the subsequent two meetings of UNEP's Governing Council gave great importance.

The Declaration on the Human Environment, drafted at Stockhom and adopted by the General Assembly of the United Nations proclaims that "in the long and tortuous evolution of the human race on this planet a stage has been reached when, through the rapid acceleration of science and technology, man has acquired the power to transform his environment in countless ways and on an unprecedented scale. Along with it, the capacity of man to improve the environment increases with each passing day

The Declaration further states, in Principle 18, the common conviction "that science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risk and the solution of environmental problems for the common good of mankind".

Recommendation 96 of the Stockholm Conference calls for the establishment of a programme to train and retrain professional workers in various disciplines at various levels and recommends to Unesco and all the organizations concerned to develop their activities in studying desirable innovations in the training of specialists and technicians.

My brief remarks are not intended to be a technical contribution to your discussions but to bring the "view from Nairobi" in order to place them in the perspective of the UNEP programme.

The broad mechanism of man's impact on his environment involves three levels, the government or decision-makers, the technical specialists and the public at large. It is easy to see that members of the engineering professions play a key rôle at each of these levels:

as public officials;

as technicians in their respective fields;

as enlightened members of the public and opinion makers.

Professionally, they can contribute to a better environment in several crucial capacities:

acting as government officials they should be able to initiate public action, as the ones who draft laws and regulations. Their studies will permit the political process to play with better knowledge of the possible alternatives;

acting as planners and builders of infrastructure they should be able to consider the consequences of their work in a longer time perspective, wider space dimension and from the points of view of other disciplines as well;

acting as working engineers they should be able to consider the implications of alternative technologies on scarce and non-renewable resources and be able to foresee, not simply respond, to outside challenges which are posed, e.g. by the energy crisis, high labour costs, short-term materials shortages and others.

If these rôles of the engineering profession are kept in mind a few points can already be noted with regard to education and training.

The first is that the growing pre-occupation with environmental concerns will create an additional demand for engineers. Can one attempt to quantify this demand in the industrialized and the developing countries and draw some conclusions as to the training facilities required?

Secondly, the training or recycling of practising engineers and the education of engineering students each call for suitable techniques. What additional research is necessary, what are the successful experiments that can be duplicated, what recommendations can this meeting make as to the structure of curricula?

Thirdly, environmental management would have to be better defined. In order to do so UNEP has commissioned the Massachussetts Institute of Technology to study what are the various rôles which must be performed for effective environmental management and what are the bodies of knowledge that underlie it.

In conclusion, the problem we face is to give engineers a broader perspective from which to see their work not just as a series of problem solving exercises. They can contribute a great

deal to a fundamental reappraisal of values and must take sides on specific environmental issues where the potential for conflict is high. Conflicts will be resolved within the local, the national and the world community, always keeping in mind that there are outer limits to development and change that condition man's survival on a small planet.

We in UNEP look forward to, and stand ready to finance, detailed recommendations for action that will stress not only the technical and economic components in the education and training of engineers, but also the effects of technology upon the earth as a limited life-sustaining system, its effects on human health and on the whole series of imponderables that constitute human happiness, nothing less - in fact - than a marriage of the two cultures which is the very special vocation of Unesco.

ADDRESS BY MR. ALEXANDER EUSTAFIEV
DIRECTOR OF THE DIVISION OF
TECHNOLOGICAL EDUCATION AND RESEARCH

Ladies and Gentlemen,

The Assistant Director-General for Science has already introduced you to some features of Unesco's activities in the field of natural sciences and their application to development, particularly as regards environmental quality preservation and the Organization's co-operation with the recently created United Nations Environmental Programme (UNEP).

I wish to briefly give our distinguished participants some additional elements which I hope would be useful for their deliberations on the work of Unesco in the area of engineering and technological education and training. The implementation of this part of the programme is the responsibility of our Division of Technological Research and Higher Education, which deals in the broad field of education and research in the applied sciences.

From the early stages of the development of Unesco's international co-operation activities in the field of basic and applied science, particular attention was given to the needs of Member States in the field of engineering education. During the 50's decade, advisory services were provided to developing countries at their request and within the limitations of the available budget of Unesco as well as of extra-budgetary resources -- for particular problems in the expansion and upgrading of their systems of engineering and higher technological education.

The decade of the 60's is marked by the increasing availability to the Organization of resources outside its own Regular Budget from the United Nations programmes of technical co-operation, such as the present comprehensive assistance scheme known as the United Nations Development Programme.

Under such extra-budgetary financing Unesco - in response to the urgent demands of Member States - was able to launch and consolidate a sizeable enterprise consisting of integrated projects aimed mainly at the creation of new engineering and other higher technological education institutions and to the expansion and reform of existing ones. Member States' institutions were thus able to receive significant assistance in the form of services of international expert personnel, fellowships for the training abroad of national teaching and research staff; laboratory, computer and library equipment; bibliographical material and, in some instances, sub-contracts for special technical services. Such inputs added to national counterpart contributions in staff, buildings and local financing permitted to develop a significant part of the institutional structure needed for this type of education in more than 50 countries in all regions of the world.

In addition, international co-operation activities in the field of engineering and technological education under Unesco's Regular Programme have permitted to establish direct working relationships with institutions in practically all Member States, specially developing countries. Our efforts to create and strengthen regional mechanisms for co-operation in engineering education are an important feature of this work, and one in which a number of you have played leading parts. Also, under our Regular Programme, we have international working groups actively examining problems that we regard as priorities, such as curricula design, continuing education and education - industry co-operation.

Talking now more about the present, let me say that engineering and technological education in the decade of the 70's is characterized - despite continuing needs for quantitative expansion - by a crisis of quality, of needs for innovation, underlined by the growingly urgent demands of societies which are undergoing an accelerated process of change.

Therefore, the problems which you are now called to examine and advise the Organization about, are complex and fascinating, rich in philosophical implications, and demanding as much insight to come from the socio-humanistic disciplines as from the scientific and technical ones. I think this is so if only because these problems at the same time that relate the human environment, concerning the education and training of human beings.

Therefore, I wish to invite you to give consideration among the factors of major importance in your discussions, to the fact that the Organization has acquired experience and established solid relations of co-operation with governments and institutions - as I already said, especially in

developing countries - on the basis of the efforts carried out in the 60's under our UNDP - financed projects in engineering and technological education.

I believe that the time has now come for Unesco to respond to new needs in Member States for the modernization of their engineering and technological education systems. In this sense the introduction of environmental studies can be an innovation of far-reaching consequences.

The existence of our network of Unesco assisted engineering and technological education institutions could be an interesting point of departure for the many activities which the Organization should undertake in the future.

I am confident that with your competent advice such a programme will grow to become a meaningful response of the Organization to the needs of our Member States.

Annex V

THE ENVIRONMENT AND ENGINEERING EDUCATION

by L. J. MOSTERTMAN*

The engineer and the environment

The growing concern for the state of the human environment has an increasing influence on nature of the engineer's responsibilities. Consequently the time perspective as well as the scope of his work is changing. Where in the past his primary aim was the well-being of the present generation, he will now also have to consider his influence on the living conditions of future generations and even on the possibilities for mankind to offer its members also in future a life in human dignity. The insight has grown that the interdependency among the consequences of various engineering works and between these works and the state of the natural environment is much stronger than was assumed in the past. Rumours about unfavourable or unwanted environmental consequences of engineering activities have caused the general public to become more critical about the engineer's activities. In almost all countries of the world this public is better informed than ever before. The belief in the value of the advises of professional experts has decreased. Each engineering organization will have to inform the public on the environmental consequences of its activities. Public participation in decision-making becomes essential.

In considering the impact of the environmental concern on engineering education these circumstances should be kept closely in view. They will, therefore, be treated now more in detail.

Multidisciplinarity

Dealing with relatively narrow areas of knowledge, as separate entities has made great contributions to the rapid advance of technology. It has led, however, at the same time to neglects in the consideration of interrelationships and of long-term effects.

The state of the human environment is determined by many tightly interwoven factors. Society responds to changes in these factors in a variety of ways. The diagnosis of environmental conditions, the prediction of the ways in which they are influenced by the engineer's works and the management of environment-related processes require, therefore, concerted action from various disciplines. How to organize such interdisciplinary studies and actions is still largely unknown. Although those participating in such studies should have a wide enough general scientific background, multidisciplinarity is more a matter of attitudes than of variety of information. One cannot consider, e.g. a teaching programme for architects in which subjects as biology, social and political sciences, preventive medicine, etc. are taught to be multidisciplinary, however useful such a wide orientation will be. Multidisciplinarity requires that people from different backgrounds learn to work together in the solution of specific problems. They must be able to listen so well to others that their contribution will be well-concerted with the contributions from other angles. They should furthermore be able to express their own viewpoint in such a way that others can easily grasp where to connect. This is not a very easy task. Often multidisciplinary teamwork results in superficiality. It is an established fact that most people perform best when they work in a relatively narrow framework, aimed at well-defined targets. Professional university training has imposed for each different speciality a specific conceptual framework; those having studied a specific type of engineering have been imbibed with a specific methodology for coming from observational data to a set of conclusions and proposals.

The existing trends towards more specialization in engineering cannot be arrested. Depending on his environmental responsibilities the engineer will, however, need a broad basic knowledge and the attitude necessary for multidisciplinary work. This attitude cannot be acquired by listening to lectures; it should be exercised. For this purpose material is needed for relevant case studies. The student from each of the various participating disciplines will have to prepare his part before the communications session begins. The teacher who acts as convener of the

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sessions should have a good feeling for synthesis and he should not try to impress his own viewpoints upon the group. One should not expect, however, that an ideal multidisciplinary group can be formed.

The question would be justified whether this multidisciplinary work would not generate a new interdisciplinary environmental science or technology. The history of typically interdisciplinary sciences narrowly related to the environment as geography, .. shows how contributions from various angles have ultimately been welded together into a new discipline. Without doubt new interdisciplinary sciences related to specific environmental technologies or to specific problems of environmental concern will start to appear in the coming years. The need for all-encompassing multidisciplinary environmental studies and actions will not be reduced, but possibly even increased by such developments.

Basic environmental subjects

Participants in multidisciplinary environmental teams should be familiar with a number of facts and principles from basic disciplines as biology, meteorology, geology and geochemistry. They should further become aware of the nature of environmental risks by reading on a few cases of unfavourable consequences of human actions. One should not engage, however, in the formation of a well-rounded generalist as they have existed in the Renaissance.

Very much of this basic matter should and could be taught at secondary level. As the engineer's works may have a great impact on the environment he should know more about general environmental subjects than the average secondary school graduate.

These basic environmental subjects could be introduced into the engineering curriculum in various ways. Much will depend on the philosophy of the individual college. Some would try to teach these subjects in a formal course including examinations. Others would prefer to make them part of a "general studies" programme conducted parallel to the main course. In many cases, it would not be necessary to cover all basic material in series of lectures. Many excellent and very readable books have been published and also public information media and the professional press are giving good reports on specific cases. One should strive, therefore, at limiting class instruction only to subjects that require formal teaching because e.g. laboratory demonstrations or individual laboratory work are needed.

Teaching basic environmental subjects in the first college years might be considered by some as being undesirable because it interferes with the formation of the main subject. Introduction of them at the end of the course or even in a special post-graduate course will have the advantage of students with more maturity. Taking the environmental subjects in the first years will on the other hand enable teachers in the various applied engineering subjects to refer to this material.

In many countries the scope of introductory environmental subjects at college level could be reduced after they have been better developed at secondary schools.

Systems concepts

For a future historian of science it would be an interesting task to investigate in how far the advent of the electronic computer a few years before the world-wide awareness of an environmental concern is a mere coincidence. In any case the computer has made possible investigations which contributed largely to our insight that society might face an environmental crisis. Many environmental studies could hardly be performed without computer assistance. Predicting future states of the environment requires the application of simulation techniques. In the study of environmental systems many variables and parameters from nature and from society are simultaneously dealt with. Pathways and dispersion of pollutants in surface and underground waters and the air have to be studied in detail.

The formulation and organization of complicated problems in a form fit for the computer has led to the systems concept. This has been widely applied to physical systems and to the management of industry. Still much has to be done before systems analysis will be well applicable to environmental situations in the public sphere in which commonly social variables play a rôle. One can readily assume that this will be the case within a few years. The engineer with environmental responsibilities would then need sufficient insight in systems analysis.

The ideas behind the systems concept can best be assimilated when they are taught at an early age. They should, therefore, belong to first-year's colleges programmes together with numerical methods and computer programming. More advanced applications can be studied later.

For many engineering students who later have to take a responsibility for environmental management this will have to be followed by courses in operational research and in management methods.

Public participation

In dealing with environmental matters, the engineer should not take a defensive conservationist attitude, but have a more constructive posture. His ideas should, however, be acceptable to the general public. He will only be able to obtain this consent when he succeeds in convincing others. Members of the general public are nowadays well aware of environmental issues pertaining to their own environment. The engineer will only be credible if he shows that he has studied the various sides of an environmental issue and is aware of which interests could be involved. He should know how to obtain participation by others in decision-making and how to communicate with the informed layman.

Textbooks often deal with examples from a limited part of the world, particularly a few

industrialized countries. The engineering student would widen his perspective and at the same time serve his community when he would work out in college environmental cases from his own surroundings. Classwork conducted in task-groups of students, teachers, and persons from outside the university can increase the student's ability to co-operate. Publication of the results of such studies in readily assimilable form would constitute a service to the community as long as imbalances between various viewpoints and interests are avoided.

Here again it is not in the first line a matter of theoretical knowledge of communicational techniques, but of the right attitude. A sensitivity for the desires and the possibilities for others to participate can only be acquired by direct confrontation with the issue.

The environment and engineering education

Multidisciplinarity, the use of systems concepts and public participation belong by no means exclusively to environmental management. They are applied to a growing extent in a variety of engineering fields. Adaptation of engineering curricula to environmental requirements will thus make them at the same time more suitable for other needs felt by modern society. It would be worth while to investigate how the introduction of the above concepts in a specific curriculum could be adapted to serve not only the environmental aspects but also the main engineering subject for which the curriculum has been designed. One would also have to consider how far the division of engineering into specific professional profiles, which have been generated in an ongoing process that lasts already for more than a century, would be influenced by such developments.

Types of environmental education at engineering schools

Engineering schools would be required to offer environmental education for the following purposes:

1. Creating an awareness of the environmental issue and of the possibilities to deal with environmental problems in general.
2. Giving the ability to deal with the environmental aspects of subjects belonging to the curriculum of a specific engineering programme.
3. The education of specialists in environmental techniques.
4. The education of specialists in environmental management.

1. Every citizen should be aware of the relations of his community and its members with the natural environment. These will be determined to a large extent by social and cultural variables. The higher the educational level is, the wider should be the scope of this awareness and the greater its depth. It is not just a matter of teaching more biology or sociology but the individual should get a clear view of his place in the world, of his possibilities to contribute to the well-being of its citizens and his responsibilities to avoid environmental damage.

2. In the consideration of environmental aspects of various engineering subjects, one would not only have to cover additional environmental protection techniques but one should also consider consequences of existing practices. One would discuss how to economize on energy and materials and their reuse. Transport quantities and distances could be diminished by using local materials. Public health care does not only mean the avoidance of vectors causing diseases, but also the design of engineering products in such a way that they contribute to the sense of psychological and social well-being. Construction and manufacturing procedures should be chosen which cause less noise, dust and waste.

Textbooks and manuals in engineering should as far as possible be adapted to environmental requirements. By a well-prepared information programme engineering teachers can be assisted with the adaptation of the contents of their lessons.

3. Specialists in environmental techniques are trained at various institutes. For the rural environment the agriculturalist is in a certain sense the environmental specialist "par excellence". The same holds for the forester in the case of the natural environment. Schools of agriculture and forestry have already understood their responsibility in this respect long ago.

Specialists in water purification and waste management have already been educated for more than half a century under the name of "sanitary engineers" or "environmental engineers". Recently a few programmes have started, aimed at the education of biologists and chemists to work together with engineers as environmental technologists, specialized in monitoring and analysing water, air and food. In most cases environmental engineers and technologists are educated on post-graduate level. As much has already been published in recent years on such programmes, they will not be discussed in this paper.

4. Many engineers would be called upon in their career to become environmental managers, although this task would not be exclusively in the hands of engineers. Industrial management techniques are only partially applicable in the public sphere. Special programmes for environmental managers should, therefore, be organized. Such programmes would encompass techniques of data collection and prediction, study of economic and social variables, standards related to the susceptibility of man and other parts of the biosphere to environmental changes and above all ways in which optimal solutions could be obtained. Furthermore, environmental legislation and administration would have to take an important place. It will be necessary to follow closely the experiences gained with a few such programmes that are already being organized and to try to organize a few more pilot projects for education in environmental management.

ANNEX A

WHAT EVERY ENGINEER SHOULD KNOW ABOUT THE HUMAN ENVIRONMENT

1. The earth

Theories about the early history of the world. The origin and changes in composition of the atmosphere. The various elements in the earth's crust.

2. The energy cycle

Units of expressing energy. Solar radiation and reflection. Conversion of energy at the earth's surface.

3. The atmosphere

Nature of the various layers in the atmosphere and the stratosphere. Heat circulation. Winds.

4. Life on earth

The metabolism of protists, animals and plants, particularly photosynthesis and respiration. The evolution of life.

5. Material cycles

The most important material cycles particularly those of nitrogen, carbon, oxygen, hydrogen, phosphorus and sulphur.

6. The water cycle

Precipitation, evaporation, run-off and infiltration. Ground waters and surface waters.

7. Minerals

The concentration of specific minerals and hydrocarbons at a few places on the earth. The notions: reserve, resource and resource base. Possibilities for prospecting and exploitation.

8. Soils

Some principles of geochemistry. Origin and nature of soils. Soil degradation: erosion, salination and lateritisation.

9. Settlement by man

The history of the settlement of man on the earth as a process of increasing specialization: gathering and hunting, fishing, agriculture, trade, transport and industry.

10. Growing populations

Relation between specialization of man's activities and population growth. Limits for population density given available resources and organization of community.

11. Man's relation to nature

Principles of ecological balance between various living species. Irreversible changes brought about by man. His parasitic diseases.

12. Man as a user of resources

Exponentially increased consumption of resources causes growing transport and exhaustion of known reserves.

13. Man as a pollutor

Excessive discharges of degradable organic materials. Introduction of synthetic organics. Spreading out of what were once locally concentrated organics. Influence of these pollutants on the atmosphere, oceans, lakes and rivers.

14. Inequalities in resource distribution

The distribution of natural resources over the earth. Their exploration, exploitation, transport and valorization. Ecological consequences of the unjust differences in opportunities to draw upon the earth's resources between various parts of the world's population.

15. Man's habitat

Physical and psychological needs for shelter and privacy. Homeostasis. Ventilation. Houses as shelter for the parasites of man.

16. Human settlements

Settlement patterns, their historical, political, geomorphological and economical origins. Environmental considerations in planning. Needs for integrated regional planning.

17. Water pollution control

Properties of natural waters. Principles of collecting liquid wastes. Breakdown of organic wastes by treatment. Sludge disposal. Non-organic and industrial wastes.

18. Air pollution control

The composition of the atmosphere. Sources of air pollution. Health consequences of air pollution. Possibilities for prevention.

ENVIRONMENTAL CONCERNS AND THEIR IMPLICATIONS FOR EDUCATION(1)

by Daniel A. Okun(2)

"Relevant" is the trendy word in educational circles in most of the industrialized countries today. For the remainder of the world, in Asia, Africa and Latin America, the word might be "development". They are but two sides of the same coin. Environmental concerns are certainly relevant today and they have an inextricable relationship with development as well(3).

Environmental degradation has been attributed to development - but development has been responsible for environmental enhancement as well. The environment can no more be preserved inviolate from people than the surface of a still lake can remain placid when a stone is scaled across it. The "conservationists" who would have us avoid upsetting the "balance of nature" might as successfully leash the winds and the waves. René Dubos (1965) in his Man Adapting put it well:

"All technological innovations, whether concerned with industrial, agricultural or medical practices, are bound to upset the balance of nature. In fact, to master nature is synonymous with disturbing the natural order. While it is desirable in principle to maintain the 'balance of nature', it is not easy to define the operational meaning of this idea. Nature is never in a static equilbrium because the interrelationships between its physical and biological components are endlessly changing. Furthermore, man placed himself apart from the rest of nature when he began to farm the land and even more when he became urbanized. The survival, let alone growth, of his complex societies implies that he will continue to exploit and therefore upset nature. The real problem, therefore, is not how to maintain the balance of nature, but rather how to change it in such a manner that the overall result is favourable for the human species."

This charge is manifestly a mandate to education, to the education of all sectors of all populations: the professional environmentalists, engineers and physical scientists, who provide the information as to the many options available and their effects, both beneficial and detrimental; the social scientists, who help devise the instruments and institutions for assessing these options and implementing them; and the people who must in the final analysis elect from the options available based upon their society's goals.

The engineers and the scientists of the world speak with one tongue, the people of the world with many. The language of the engineers and scientists is a language born of industrialized society, and while the people of the industrialized countries may hope to understand it, to most of the people of Asia, Africa and Latin America, it is gibberish. The Indian engineer or scientist has far more community of interest, and spirit, with his colleagues in the United Kingdom than with the mass of people of his own country. It is not difficult to understand, therefore, why the transfer of technology from the industrialized countries to the others has often created more problems than it has solved, for the options presented are options that are foreign to the people whom they affect.

Therefore, in evaluating educational needs for environmental management, sharp distinctions need to be made between the industrialized and developing countries, and sometimes between different societies in each country, which may best be characterized as rich or poor. In the industrialized countries, the qualify of life and the availability of the fruits of industrialization are not much different in urban and rural settings. Exceptions do exist in the United States of America, for example, in the slums of cities and in depressed rural areas. The failure to perceive these exceptions has already gone far to frustrate the environmental movement. The typical question: why should the blacks of Harlem (in New York City), living in squalor, be concerned with the quality of water in the nearby Hudson River, a river they seldom see from sun-up to sun-down? If the conservation or environmental "movement" is of little interest to some peoples in the United States of America, how much impact is it likely to have on the poor of developing countries, who are in the vast majority?

A recent experience of the author may illustrate the point. On a recent visit to the capital city of a large country in South America, he was invited to address a lay "ecology" group, made up of leading intellectuals of the city, and the scientific staff of the Ministry of Natural Resources. The chief question raised in both groups concerned a recent government decision to authorize the purchase of a plant for manufacturing hard detergents. How could this be justified, they asked, in the face of the fact that hard detergents had virtually been outlawed in Europe and the United States? There was not then, nor was there likely to be in the near future, a single biological wastewater treatment plant in their country. Making a detergent biodegradable involves greater cost, but hardly any benefit accrues where no biological treatment is available to perform this biodegradation. A soft detergent would

(1) For presentation at Unesco meeting, "Environmental Aspects of Education and Training of Engineers", Paris, June 1974.

(2) Kenan, Professor Environmental Engineering, University of North Carolina at Chapel Hill and Visiting Professor, University College, London.

(3) However, we must not lose sight of the fact that education for education's sake, to preserve, enrich and pass on the legacy of the past in literature, the arts and philosophy, is also relevant and essential to sound national development.

impose a cost burden on all who use detergents, rich and poor, in cities and towns, with no discernible benefit, simply to be in environmental "fashion".

The environment in industrial societies

The "great environmental awakening", just as the "great sanitary awakening" more than a century ago, is a product of industrialized society. The litany excoriating technology for destroying the environment is far too long, tedious and well known to even attempt to recount here. That much of it has merit does not make the sermon more enlightening as it begins to repeat itself. Much of the "new" consciousness resides in the minds of the affluent of the industrialized countries, and as the people of some of these countries are largely affluent, this consciousness is important to the populace and, if properly engaged, to the industrialized society as a whole. Even those not so affluent have become concerned with their environment. Lengthening age spans, accompanied by earlier retirement, together with more leisure time during one's working life in the industrialized countries have encouraged people to exploit their surroundings and to demand more from their governments in improving their environment.

Protected from disease and death at an early age, people in the industrialized countries now live on to succumb to the chronic diseases. The rôle of environmental insults, including the long-term effects of low-levels of trace chemicals to which people in the industrialized countries are exposed, needs evaluation. The environmental monitoring of trace chemicals is costly and difficult, and the determination of their epidemiological significance most complex. Chemists and epidemiologists are understandably loath to enter upon such investigations. The engineer, if he is educated to understand the issues, will articulate problems because he needs the answers, and thus might be the catalyst for initiation of the studies.

The need to consider the environment and its impact on man as a unity is becoming daily more evident. Just as the pressure on the shell of a gas cylinder increases as more molecules of gas are compressed into it, so too the pressure on our environment increases as more people are crowded into the same space. When the gas in the cylinder is heated, the molecules move faster and the pressure increases to a point at which the cylinder may burst. So, too, people have been invested with higher velocities and with more energy than they may use intelligently. The result, great stress on our environment, and reaction stress on the people in it.

The profligate use of energy, exhausting the resource as it pollutes the environment; the despoilation of land resources by uncontrolled land speculation for growing populations; pollution of the seas and oceans; the increasing cacophony of environmental insults in urban communities, challenging the quality of life; etc. etc. cannot be dealt with simplistically. Solutions require the talents of a wide variety of disciplines. And, in the fashion of the day, educational institutions in many of the industrialized countries have begun to respond. Little justification for a commitment to the environment of the developed world is required and none is offered here.

In fact, in the United States, the educational response to the fashion has been typical of the "go-go" attitude, to take advantage of the sudden interest by the young and, more importantly, to profit from funds to be made available by a concerned government. A plethora of "environmental" courses - environmental law, environmental economics, environmental medicine, environmental sciences of every description, even environmental ecology - and new institutes, departments, centres, and even entire colleges and universities dedicated to the environment have sprung up overnight. Exhaustive and exhausting catalogues to this new enthusiasm are available. However, many institutions were slow to respond to this new "glamour" field - conservative, old-fashioned faculties resisting the blandishments of easy relevance and easy money.

As in all things, moderation might have been best. Youthful interest has flagged, and a financially embarrassed government has withdrawn its support. Some programmes have succumbed. Others, more slowly and soundly built, based upon a tradition of environmental concern extending back half a century, are today sources of strength to the society.

This paper does not explore the alleged disastrous environmental consequences of rampant technology and population growth. "Doomsday" volumes have appeared in profusion and joining the debate here would serve no useful purpose. Some industrialized countries over-reacted, with laws and standards impossible to implement or, where possible, with costs to society not carefully calculated. However, the pendulum is beginning to swing back and it appears likely that a proper, if precarious, balance will be attained. More important, the industrialized countries have spawned large numbers of environmental interest groups that have often been a match for predatory industrial organizations. On the other hand, the environmental consequences of progress in the developing countries are scarcely ever assessed by either the government itself or by donor or lending agencies.

The environment in developing countries

The problems of the human environment of the developing world, in Asia, Africa and Latin America, are substantially different from those of the industrialized areas of the world. This is clearly evident in Figure 1 (Bryant, 1969), where the health problems of the developing world are primarily the infectious diseases that result from a hostile environment: malaria, tuberculosis, diarrhea and dysentery, and environmental deficiencies generally.

The table below (Le Riche, 1967) is illustrative

of the order of magnitude of these infectious diseases, all of which, except the least common, leprosy, are directly related to environmental deficiencies.

Illustrative magnitudes of infectious diseases

	(Order of magnitude)
Helminth (worm) infestations	3,500,000,000
Hookworm	700,000,000
Schistosomiasis	200,000,000
Onchocerciasis	40,000,000
Tuberculosis	40,000,000
Malaria	25,000,000
Leprosy	10,000,000
Trachoma (with 1% blindness)	400,000,000

"Enteric diseases (intestinal infection plus malnutrition) occur as repeated episodes in over half of the children in developing countries. Together, the malnutrition/infection combination accounts for approximately 15,000,000 of the total 30,000,000 children under five years who die each year" (de Haas, 1967).

In an excellent review of the "Key problems impeding modernization of developing countries", Howard (1970) states "The pollution of soil and water with human waste, and the subsequent contamination of food and drink, produce infection which, in combination with malnutrition, lead to the largest single category of disease in children".

On the other hand, in the industrialized countries the health problems are the chronic diseases; diseases which appear in people protected from infectious disease.

In his classic work Asian Drama: An Inquiry into the Poverty of Nations, Myrdal (1968) states "the greatest problem of all is perhaps the disposal of human waste".

Cholera is endemic in India and Pakistan and according to Myrdal: "The incidence of other waterborne diseases, such as typhoid fever, dysentery, diarrhea and diseases caused by intestinal parasites, is extremely high throughout South Asia. Most people in the region suffer chronically or intimately from one or more of these diseases. The high rate of infant mortality is partly due to the prevalence of diarrhea and other waterborne diseases, but aside from cholera, diseases in this category are rarely fatal except in early childhood . . . The only effective way to fight all of these diseases is with improvements in sanitation and hygiene".

The World Health Assembly in 1966 listed environmental deficiencies, as exemplified by water, as first in importance in the world's health problems, and populations are growing in the developing countries faster than in the industrialized areas. More significantly, the migration of population from rural to urban areas in the developing countries is increasing rapidly, much more rapidly than has been anticipated. In Latin America, where data may be more reliable than in Africa or Asia, the following is illustrative (Wolman, et al., 1972):

	Rural	Urban	Total
	Population in millions		
1961 population	107	102	209
1971 population	127	164	291
% increase	18.6%	61%	39%
1971 population predicted in 1961	131	149	280

In an excellent paper on "Disease and development in Africa", from which much of the content of this paper as related to Africa is drawn, Hughes and Hunter (1970) state: "Urbanization is perhaps the most salient social and economic feature in the life of Africa today. While populations of African countries are doubling in a period of from 25 to 40 years, African urban populations are doubling in less than 15 years. In Senegal, the towns have increased by more than 100 per cent in a decade. Enugu, in Nigeria, was an empty site in 1914 and now has a population of more than 80,000; Ibadan, also in Nigeria, has trebled its population in 20 years. And much of this population concentration is packed into the peri-urban fringes, slums and shanty towns".

In an excellent review of "The exploding city", preparatory to an international conference organized by The Sunday Times (London) (1974) and the United Nations, in April 1974, the 12 fastest growing large cities in the world are listed, all to more than double by the 1980s. These cities, ranging in size now from more than one to almost ten million, are all in Asia, Africa and Latin America. It is estimated that 60% of the 2,000 to 3,000 million additional population to inhabit the earth in the next three decades will find their way to the burgeoning cities of these three continents, cities which today cannot provide the basic facilities necessary to sustain life. Even one of the largest and most wealthy of these cities, Sao Paulo, provides water supply to only about half its population.

The significance of this rapid urbanization on the environment is evident to the most casual world traveller, even as he goes from the modern airport to his modern hotel, in any large city in Asia, Africa or Latin America. The situation has been graphically described by the World Health Organization (1960): "The influx of immigrants into the towns leads to overcrowding, which in turn produces water shortages, overloading of existing sewage disposal systems, the creation of fresh sanitary problems in towns without such systems, and the risk of spread of infectious diseases. The rural immigrant is the least adequately protected of all town-dwellers from the standpoint of environmental sanitation because of his poverty and his ignorance of the ways of the town. He is poorly housed and badly fed; he is without access to a wholesome water supply; his personal hygiene is of the lowest standard. Sanitary measures seem to be designed less to protect his health than to protect the town community from any infection he might carry. His attempts to earn a living by hawking food and drink, for example, are frowned upon. His very presence in the town is discouraged, not only by

the health authorities but also by the police. He accordingly settles outside the town, entering it daily to look for employment; and the overcrowded insanitary hovels in which he and his fellow-immigrants live form the peri-urban slums, the 'shanty towns' of modern Africa. From the sanitary aspect Engel's description of the Manchester slums in 1844 is applicable to these shanty towns. Sanitation is non-existent, and open drains run down what passes for streets. The shanties are built of mud and wattle, old packing-cases, or kerosene tins, with tattered blankets as doors. Children crawl among the uncollected rubbish or in the drains. Water has to be fetched from a pump, well or tap, and may be contaminated. The atmosphere is unlikely to be polluted, as it was so often in Industrial Revolution towns, and the warmer climate leads to life being spent out of doors to an extent not possible in more northern latitudes; but the climate also encourages a vast number of flies and mosquitoes and, in places, the snails which transmit bilharziasis. Occasional floods convert the ground into a quagmire. Malaria, the diarrhoeal diseases, tuberculosis, bilharziasis, and the helminthiases all abound. Malnutrition is common, with its train of deficiency diseases and kwashiorkor. The destruction of tribal traditions and the general social disorganization lead to alcoholism, prostitution, and venereal disease; and mental disorders are frequent. Morbidity and mortality are both high."

The urban centres in developing countries also have their environmental problems: air pollution in Rio de Janeiro, traffic problems in Bangkok, inadequate sewerage and drainage in Jakarta, and undependable and unsafe water supply almost everywhere. These cities are like carnivals - initially attractive, but a closer examination reveals grime and grubbiness underneath. The necessary infrastructure has not kept pace with urban development.

While some of the problems of urban centres in developing countries seem little different from those in the cities of the industrialized countries, several factors distinguish them from similar problems in the industrialized countries:

(1) Because infectious disease is far more prevalent in developing countries, a breakdown in the infrastructure can be calamitous. For example, inadequate public water supply, whether from unexpectedly severe drought or from inadequately-sized facilities, in an industrialized country causes no more than inconvenience. In a developing country, such a situation leads to new outbreaks of water borne disease;

(2) the developing countries generally do not have the economic resources to devote to such problems. They are difficult enough to amass in the industrialized countries;

(3) the developing countries do not have the institutions to deal with such problems. Such institutions are only now being created in the industrialized countries;

(4) the developing countries do not have the manpower, or the educational resources to create the manpower, to deal with these complex urban problems, problems seldom responsive to simplistic solutions.

This situation has been recognized by the Pan American Health Organization (1969), the World Health Organization Regional Office for the Americas, where the shift from developing to developed is beginning to occur at various points in the hemisphere.

"In the years ahead the governments will have to cope with environmental problems of greater magnitude and complexity. Advancing technology will leave in its wake a more sophisticated array of human stresses. Environmental contaminants will increase and will broaden from microbiological pollutants to those having their origin in chemical substances. Long-term exposure to toxic substances will be more significant and more difficult to diagnose, with wide separation of cause and effect. The growth of cities will aggravate problems of traffic congestion, accidents and noise hazards. Population densities and poor housing will increase the hazards of communicable diseases and problems of mental health. In industrial complexes, occupational health will require more focused attention and remedial measures."

Challenges to the rural environment in developing countries

Just as Myrdal explores the Asian drama, Kimble (1960) identifies the actors in the African drama:

"In the African social drama sickness has a strong claim to being arch-villain. It is bad enough that a man should be ignorant, for this cuts him off from commerce or other men's minds. It is perhaps worse that a man should be poor for this condemns him to a life of stint and scheming, in which there is no time for dreams and no respite from weariness. But what surely is worse is that a man should be unwell, for this prevents his doing anything much about either his poverty or his ignorance."

Hughes and Hunter (1970) catalogue the myriad disease, all deriving from an environment allowed to run amuck, that afflict rural Africa.

Item: an average of two infections per person.

Item: schistosomiasis (bilharziasis) affects half the population, with some districts exhibiting 80 per cent infection rates.

Item: in some rural areas, more than 80 per cent of the children harbour hookworm infestations.

Item: in some rural villages on the Congo, more than 65 per cent of the population are ill with filariasis.

Item: of some 70,000 examined in Upper Volta, the malaria infection rate was 94 per cent.

Item: with a malaria infection rate of about 50 per cent generally, the rate in Tanzania for children under the age of five exceeded 80 per cent.

Not only are these infections debilitating in their own right, but as Chandler (1957) points out, a heavily parasitized individual needs more food than a healthy person.

It has been estimated that control of enteric disease of environmental origin in India would have the effect of increasing the food resource

by 10 per cent an amount that might well be the difference between survival and famine for a substantial segment of the population.

Unfortunately, development projects, particularly those initiated and executed by the industrialized countries in so-called "aid" programmes, often exacerbate the situation. Hughes and Hunter have summarized the types of impacts: "... affecting man/environmental relationships which, while they may not in all cases be part of the explicit goal of any given development scheme, are nevertheless involved in the course of the implementation of the scheme. Aside from major purposes, abstractly stated (e.g. 'to raise agricultural productivity'), what other kinds of changes often come about under the aegis of 'development' which have obvious relevance to health status of the population?

(1) overall changes in man/habitat relationships (e.g. working in new farmland or under other new geographical and geozoological conditions: relocation to different climatic and zoonotic areas);

(2) increased population movements, mixing, and concentration (e.g. building of roads, railways and other transportation networks; migration of people to towns and sites of economic opportunity such as mines, factories, hydroelectric or irrigation projects; relocation of communities, etc.);

(3) change in patterns of water flow and use (e.g. building of irrigation schemes, dams and ponds; use of polluted water resources in undersanitized and overcrowded towns);

(4) change in vegetation cover (e.g. cutting down of forest or bush, altering ground cover; denudation of landscape);

(5) changes in micro-environmental conditions (e.g. changes in housing, neighbourhood, and settlement patterns; in house style and materials of construction; in location with respect to modes of transportation, sources of water, kinsmen, etc.);

(6) changes in values systems and social sanction systems (e.g. conjunction of alternative ways of life, in urban environment, or socially-heterogeneous population, as in large-scale economic schemes; the erosion of traditional systems in conditions of economic deprivation, as in urban slums, etc.)".

They go on to describe several such projects: "The Gezira area of the Republic of the Sudan provides a particularly good example of the dangers of lack of ecological foresight. The welfare and prosperity of this area is significant to the country as a whole because the Gezira provides nearly one-third of the total revenue of the country. Before 1925, the people of Gezira lived under primitive conditions, dependent wholly upon grain cultivation (mostly millet). Drinking water was scarce and drought was common. In 1918, work began on the dam at Sennar and it was completed after World War I. With the completion of the irrigation works, cotton was planted and yielded abundantly. Prosperity came to the region.

Approximately three years after the establishment of irrigation, however, disease-transmitting snails began to appear in the irrigation canals - the hosts of the disease organism making their appearance first, and not the schistosomes themselves. After that, close watch was kept for snails and schistosomes. From 1931 to 1953 the snail population increased, as did the influx of migratory workers to the cotton fields, first from neighbouring areas then from western Sudan and finally from West Africa. By 1954 half a million people worked regularly in the Gezira area, in addition to temporary migrants. In total the numbers of temporary migrants fluctuated between 150,000 and 200,000 per annum.

In 1942 attention was drawn to the ever increasing incidence of disease, which, it is believed, was introduced into the area by the migrant workers from West Africa. In 1947, field investigations in northern Gezira showed a mean incidence of 21 per cent among adults and 45 per cent among children".

That such concerns are not unrecognized is well documented by Lanoix (1958) who identified the relationship between irrigation projects and schistosomiasis. He notes that, in 1954, the Department of Health for Rhodesia warned that large-scale irrigation projects might well fail because of their effects on the health of the country. One of the first irrigation schemes established in that country after World War II is now largely abandoned because the effects of malaria and bilharzia were left out of the calculations.

One of the grandest development projects in the world, the Volta Lake in Ghana, is described by White (1973):

"The Volta Lake in Ghana is the largest man-made lake in the world, accounting for about one-fifth of the total land area of that country. After a comprehensive period of planning it was constructed under a programme which gave primary emphasis to electric power production and which planned to provide the relocation of more than 80,000 people living in the reservoir area. Pressure for opening of the generating works was so intense that the reservoir flooding began before studies of the population to be relocated were completed, and there ensued a long period of difficult adjustment in the livelihood and living patterns of people dispossessed of land and heritage. The responsible relocation authorities did provide for housing, using a somewhat ingenious unit construction plan, and tentative arrangements were made to enable various groups of people to establish themselves in new agricultural land above the level to be reached by the reservoir waters.

Within three years after the initial relocation, a substantial proportion of these housing units were unoccupied, more than half of all of the population were on food relief, and the disorganization of both community and family structure was severe. This was not because those planning the project had ignored the possibility of the impounded waters providing opportunities for spread of schistosomiasis, nor of the need for new housing, or the vital rôle of highways connecting the new communities, or the need for credit and technical assistance in developing

farming on the upland areas. Careful attention had been given to local water supply and waste disposal. The basic disorganization occurred because the planning had centred upon physical features and had not been directed at means of lasting livelihood in a tropical environment where the maintenance of soils is a delicate process, where land clearing is expensive and tedious, and where community organization and process was not well adapted to rapid social change."

Thompson (1967) describes development that led to environmental change (improvement?) that was responsible for the introduction of a population to sleeping sickness, a protozoan disease spread by the tsetse fly, Trypanasoma. An area in Nigeria to be the site of a railroad extension was surveyed and found to be free of sleeping sickness. However, a small forest preserve planted along the banks of a stream, at the point where the main road crossed, became a gathering place for people getting water, and a source of a new outbreak of disease.

Hughes and Hunter (1970) described the findings of Apted (1963):

"In 1956, the people from Muyama in the Kasulu District of Tanzania, a barren and heavily eroded area on the hillside above the Milangilizi Valley, obtained permission to go down into the valley to cultivate new fields because of pressure on available agricultural land. The valley was fertile and well watered, but much of the riverine thicket contained large concentrations of G. morsitans. For a year nothing happened and then in 1958 and in 1959, man, fly and parasite contact having been established, an epidemic outbreak of sleeping sickness occurred."

They then go on to define a "disease of development":

"Malaria, and attempts to control or eradicate the disease, provides a good case for the point that the quest for health is continuous and provides only temporary respite; for malarial programmes are waging a continual fight to keep ahead of the proliferation of insecticide-resistant strains of the insect vectors which, through processes of natural selection, adaptive capabilities and enormous reproductive capacity, are multiplying the disease threat. In a sense, the more that is done, the more the problem is exacerbated because of the need for new research to develop more effective (and more specific) insecticides. It might almost be said, then, that - unless the transmission cycle is broken at other points - insecticides spraying of the insect vector (which, in effect, creates a new environment, an environment of 'development') is an attack on a problem which, in itself, has been created by earlier spraying - a 'disease of development'."

Thus, it is clear that understanding by a wide range of professionals, and institutions that can translate these understandings into well-conceived and well-executed projects, is necessary if the environment is to be a support rather than a threat to the rural populations in developing countries.

However, so long as the professionals and their institutions are nourished by their colleagues in the industrial world, that long will their projects be foreign to the indigenous populations they are intended to serve.

An excellent example of the rôle of the local people, as contrasted with professionals, is given by Horn (1969) who describes a schistosomiasis control programme in Ching Pu County in the People's Republic of China. In 1948, an estimated 80 per cent of this rural country of 350,000 were ill with schistosomiasis. In fact, between then and 1966, 245,000 patients were treated for the disease. During 1948 some 3,500 separate waterways totalling 4,300 km. of river bank and 80,000 mu of rice paddies were infested with the host snails. By 1966 snails could be found in only 65 km. of riverbank and in 6,200 mu of rice paddies, and only 32,000 people still excreted the schistosomiasis eggs, and these were all under close supervision.

In the village of Ren Tun, some 500 had died between 1930 and 1949, and in 1949 there were 449 cases of a total population of 461. By 1966, with 671 people in the village, there were hardly any new cases.

The approach used to achieve this control is hardly that likely to be recommended by professionals from industrialized countries, who generally prefer pollution control or chemical treatment of the water to kill the snails, neither of which has been successful. Rather the approach was one that could only be implemented by the people themselves, the removal of the snails by hand. And such a programme depends upon the education and motivation of the people, and is perhaps feasible at this time in the type of rural society now found only in China. As White (1973) points out: "So far . . . no developing country receiving Western aid has eliminated malnutrition". And the same can be said for schistosomiasis, where development aid has generally had the effect of increasing the potential for spread of the disease.

Significantly, Recommendation 1 of the United Nations (1972) Stockholm Conference states "that all development assistance agencies . . . give high priority . . . for assistance in the planing of human settlements, notably in housing, transportation, water sewerage and public health . . ." and ". . . in solving the environmental problems of development projects; to this end they should actively support the training and encourage the recruitment of requisite personnel . . .".

Two years later, the Governing Council of the United Nations Environmental Programme (1974), under the category of "human health and well-being" established as its highest priority "a concerted programme for the eradication of endemic diseases . . . as soon as possible, paying particular attention to the control of vectors with a waterborne phase . . .".

Personnel requirements

A guide to the types of personnel required for making and implementing environmental management decisions may be taken from a framework

for environmental questions, in Figure 2, developed by Christman (1972). The details and institutions listed are based upon decision-making in the energy field for Seattle, Washington in the United States, but the framework is adaptable for application to any type of environmental problem anywhere. He bases his model on four categories of operation:

(1) need perception: studies of human motivation; goal and value discrimination as a function of culture, personality, and experience focused on the need for space, food, shelter, mobility, etc.;

(2) resource description and technical developments: studies of the quantity, quality and characteristics of any material useful to man; the ocean, forest, atmospheric resources, etc., and devices used to extract, convert, or use these resources;

(3) public policy: studies of institutional characteristics; governmental and private agency strategies for implementing or regulating actions affecting use of resources;

(4) effects analysis: studies of user impact on resources resulting from activities undertaken to satisfy perceived needs; development of environmental quality indicators.

From this model it is possible to glean the professional and scientific characteristics of the personnel that need to be qualified to act in each of the compartments.

Roughly, these might include, but certainly not be limited to the following:

Need perception: sociologists, psychologists, architects, nutritionists, engineers, public administrators, planners, public health specialists, politicians (as representative of people, rather than in their pejorative lineamint).

Resource description and technical development: engineers, scientists including physicists, chemists, biologists, geologists, agriculturists, industrialists, etc.

Public policy: political scientists, public administrators, lawyers, economists, financiers, planners, journalists, politicians and the people, as represented by official and voluntary local organizations, and certainly students and teachers.

Effects analysis: scientists, engineers, medical and public health specialists, agriculturists, industrialists and, of course, the people as represented by any of their chosen instruments.

It becomes quickly obvious that few are excluded from the decision-making process, in one rôle or another. As this paper is directed primarily to the professionals, their numbers and educational qualifications and preparation are the focus.

Without going into detail, it may be affirmed without contradiction that, in both industrialized and developing countries, professionals professionally qualified (as distinguished from the self-anointed) in the environmental field are in short supply. Okun (1967) has pointed out that in one of the fields of greatest concern in the developing world, community water supply, it has been demonstrated time and time again that the programmes are not slowed by shortages of water, materials, or even money, but by lack of qualified engineers and managers to plan, initiate and execute "bankable" water supply projects.

In the industrialized countries the situation is little better. The National Environmental Policy Act of 1970 in the United States, which requires environmental impact statements to be prepared and reviewed by concerned agencies for all projects that are financed by the government, which means virtually all publicly financed projects, was slow in getting off the mark because the executing and review agencies could not recruit the qualified personnel required. That many unqualified were pressed into service is only too evident in the rather cavalier treatment given to most environment impact statements.

Recognizing this need in Europe, the Regional Office for Europe of the World Health Organization (1973) has inaugurated a study of manpower requirements. Five pilot areas, varying from rural to urban, one in each of five countries, will be investigated to determine the environmental programmes and agencies operating in each area, the personnel now employed, the vacancies and turnover rate, the anticipated growth rate in each of the various categories of personnel and the manpower mix, in 1973 and 1980.

The agencies to be studied include private firms consulting organizations, construction companies and, of course, public agencies operating in the environmental field:

water and wastes;
land;
air;
urban environment;
recreation;
radiation
noise;
occupational environment;
food.

In addition the study will investigate resources for epidemiological surveys, training and research, and supporting services including legal and administrative services, statistical services, laboratory services and facilities for public education.

Such studies have obvious shortcomings, as the responsive institutions have not yet emerged, even in the developed countries. Furthermore, present employment patterns are a function of the availability of personnel, and suffer from the historically conservative structures of both government and educational institutions. These difficulties would be even greater in developing countries, whose governmental and educational institutions in the environmental field, where they do exist, are likely to be in a quite primitive stage.

Nevertheless, such studies will reveal the order of magnitude of requirements and are far better than dependence on market-place determinations of employment, which are quite unsatisfactory in the public sector. Similar studies in the developing countries will be more difficult to execute, but will accordingly be far more valuable.

The lead time required to prepare professionals, particularly if the educational facilities

need to be created, is so long that the development of the educational facilities, and the faculties to man these facilities, is a matter of greatest urgency.

Education of professionals

Because formal educational programmes take so long to establish and to yield graduates who can take up responsibilities in the environmental field, the most immediately rewarding educational programmes will be those that can build upon manpower resources already available. Exemplary of such an approach are several such programmes already established by the University of North Carolina at Chapel Hill.

The oldest is the International Program in Sanitary Engineering Design (IPSED), intended to meet manpower shortages in the community water supply field. This programme, offered 14 times over an 11-year period, and terminating this year, was intended for graduate engineers who had no speciality training in the sanitary engineering field. A non-degree programme, participants spent one term at the university in special courses devised for them, one month at community water supply facilities and then one to six months at the offices of a consulting engineering firm that specializes in community water supply, with considerable experience in developing countries. In the last years the field of specialty was extended to wastewater collection and disposal. In all, some 150 engineers from about 40 developing countries have participated. While the programme was supported by the United States Agency for International Development, participants were sponsored by WHO, other international agencies and the countries themselves. An interesting, and not unimportant, statistic about the participants in this special non-academic programme is that all but two of the participants returned to their own countries to work, as compared with only about 50 per cent who returned permanently upon completion of academic M. Sc. courses.

A similar, shorter course for engineers, directed to the economics and finance of water supply and wastewater projects in developing countries was inaugurated in 1973 by the Economic Development Institute of the International Bank for Reconstruction and Development (the World Bank). This three-month course is to be given annually in Washington.

At the initiative of the United Nations Industrial Development Organization, and assisted by the USAID, the University of North Carolina conducted an 11-week International Program in the Environmental Aspects of Industrial Development (IPEAID), Annex A. This programme was designed for government and industrial officials of developing countries, engineers, scientists, lawyers, physicians, etc. responsible for industrial planning, site selection, plant management and the like. Three weeks were spent in group visits to industrial plants and to government offices responsible for them. Individual participants then spent one week at a plant of a type similar to one they might have experienced with in their own countries.

Of all professional disciplines, engineers stand most widely accused of giving little attention to the environmental impact of their projects. Accordingly, the Office of Engineering of USAID, which has responsibility for initiating and supervising capital projects in developing countries that the United States may assist with grants or loans, sponsored a series of two-week courses (Annex B) for its field engineers, the AID Environmental Engineering Program (AIDEEP). Engineers employed by AID are brought to the University of North Carolina campus from throughout the world. In that short period, an attempt is made to help these men identify the impacts that their projects might have, and to learn where to turn for help that, up to then, they had not known they needed.

Such courses for personnel from developing countries may be useful, but they are expensive and, even if the numbers accommodated were to increase substantially, they cannot expect to meet the need either in numbers or in content because of the foreign venue, the strange language and the nature of the instruction. Their principal value lies in their "multiplier effect", the hope nurtured in each programme, that each participant on return to his (or her) country, will attempt to develop appropriate means for bringing similar programmes to those who cannot afford to leave their positions for a lengthy period abroad or who, for reasons of costs or language, are obliged to get their training in situ.

Of course, the organization of such programmes for professionals in their own countries is by far the most expeditious approach. In the larger cities, this can be handled at the universities, with courses of various lengths or with night or week-end courses. Larger industries or government agencies might arrange programmes on an in-service basis, using talent recruited from universities or national or international agencies.

The content of these courses will all be multidisciplinary and should be tailored to the needs of the participants. Syllabi for the UNC IPEAID and AIDEEP programmes are attached herewith as a guide to the diversity of material, and hence the breadth of staff, required to conduct such programmes.

It is not inappropriate that the University of North Carolina engage in these activities, because North Carolina is a "developing" State in the United States. Its population is predominantly rural, and its rate of urbanization is similar to that in developing countries of Asia, Africa and Latin America. It also suffers from similar types of hazards from inadequately considered responses to "fashionable" environmental issues. An example may be of interest:

An important agricultural crop in North Carolina is tobacco, and DDT had been used for pest control during its growth. Concerns for the ecological impact of DDT have led to legislation banning its use in the industrialized countries. Before such a ban was instituted in the United

States, European purchasers of American tobacco required that the tobacco be free of DDT residues(1). Accordingly, the United States Department of Agriculture required that to be eligible for price supports, growers not use DDT. It was predicted that the replacement for DDT, an acutely-toxic, but environmentally relatively innocuous organophosphorus compound, would exact several deaths amongst farm families in North Carolina during the next growing season. Unfortunately, the deaths did occur.

Ill-considered restrictions on the use of DDT in developing countries may be far more disastrous.

While a national or State university may have faculty resources that are highly qualified in environmental studies, the many other institutions responsible for education may not. Also, it will scarcely be appropriate for all institutions to have specialist faculty and to offer specialized programmes in the environmental field. Accordingly, the capabilities of the university can be extended, using the multiplier effect, by offering short courses for educators from these institutions, who might then incorporate environmental issues in their own teaching.

The University of North Carolina conducted such a programme, an "Environmental Protection Conference for Educators", in 1973, and the subject-matter of the conference is shown in the Annex C to this paper.

Academic courses may also be offered to those who do not expect to specialize in environmental affairs. At the University of North Carolina, one such is available for students in the public health field. "Elements of Environmental Health", while another, "Man and his Environment" is designed for students from throughout the university. The latter has some sessions devoted to less-developed country problems. Syllabi of these are also in Annexes D and E.

Professional education for engineers

If there is any one common denominator to engineering education in the industrialized countries of the world, it is that agonizing reappraisals are being made continually: general engineering vs. specific engineering fields; three years or four years or five years; one or two years of basic studies vs. early departmentalization; undergraduate vs. post-graduate specialization; and constant examination and re-examination of engineering curricula.

The thread running throughout these examinations is that professional engineers must be responsible members of society. A not uncommon view of engineers in the United States may be gleaned from the following quote from a book expounding conservation (Marine, 1969):

"... the new rapists are loose upon the land. Theirs, still, are the vicious, violent laissez-faire techniques of the turn of the century. They are not necessarily employed by lumber companies or mining companies or railroads; a lot of them work for you and me. They are the public servants who work for the Port of New York Authority or for the State Highway Commissions. They work for the United States Forest Service or the National Park Service. They are in the Army's Corps of Engineers and the Bureau of Reclamation and the Bureau of Public Roads. They are dedicated single-minded men. And when they talk – which is as rarely as they can manage – theirs is the language of fanatics.

They are called engineers."

The author's main targets are the "engineers" and the "engineering mentality" – "... the simple, supposedly pragmatic approach of taking the problem as given, ignoring or ruthlessly excluding questions of side effects, working out 'solutions' that meet only the simplest definitions of the problem". The subtitle of the volume identifies the theme: "The engineering mentality and the devastation of a continent".

As the author excoriates engineers for building jet airports in nature's preserves, motorways that tear communities asunder, reservoirs that flood villages and agricultural land, power plants and factories that pollute the air and water, the easy defence for the engineer is that he is the wrong target. The people who fly and drive, who demand the electricity and who buy the products, who elect their governments and who own shares of the companies are responsible. These engineering projects are society's projects and the engineers who plan and execute them are merely servants of that society.

There is no defence at all. Engineering leaders in every field are beginning to recognize their social responsibilities and to exhort engineers to their proper rôle. Sleicher (1968) puts it succinctly:

"The engineer who fails to appreciate human values may become a mere technological servant of those in society who make the important decisions. When devoid of sensitivity to human needs, the engineer is relegated to the rôle of hired hand."

One of America's most distinguished environmental engineers, the late Thomas R. Camp, was fond of quoting Daniel W. Mead, a past President of the American Society of Civil Engineers, in a similar context (Camp, 1951):

"It is the duty of the engineer to satisfy himself to the best of his ability that enterprises with which he becomes identified are of legitimate character. If after becoming associated with an enterprise he finds it is of unsound or questionable character, he should sever his connexion with it as soon as practicable. The engineer should engage in no occupation nor undertake any project that is contrary to law or which is inimical to the public welfare.

The engineer should discourage in every legitimate manner the construction of public works that are economically unsound for the community, State or nation."

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(1) Ironically, some 30 years of experience with DDT world wide, often with heavy exposures of population to the chemical, have revealed no effect on human health. Other constituents of tobacco may be assumed to be far more damaging to health than DDT.

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While Mead was not specifically referring to the deleterious environmental consequences of engineering projects, the engineering ethics he was urging upon the engineering profession are even more apt today.

Young people today also have a different vision of what they, as engineers, should contribute to society than did their elders, who, while glorying in proved technical achievements, tended to shun involvement in the political decision-making that their projects were to consummate. This was put very well by a young engineering graduate writing for career guidance:

"There are surely opportunities for men with a sound technical background in the various public and private programmes working to improve the quality of American life. What I had in mind are such areas as transportation and urban planning, industrial development, and air and water pollution control - which I suppose you are intimately involved in yourself ... I have a strong interest in the social sciences and would welcome an opportunity to get involved in an interdisciplinary field; in fact I would prefer that course to employment in a purely technical capacity."

Because projects that impinge upon the environment are often engineering projects it behooves the engineer to appreciate the multifaceted impact of the project and to recruit the participation of the many other disciplines who have much to contribute to the project. With respect to the control of schistosomiasis, the World Health Organization (1961) noted the need for interdisciplinary co-operation in controlling this pervasive health threat in the planning phase: "The successful attack on the disease will be accomplished by a team: the engineer, the malariologist, the parasitologist, the sanitarian, the physician, and the chemist, widely divergent in training, speaking in the beginning different technical languages, but with a common purpose in mind." They might well have added the sociologist.

Therefore the engineer must have an understanding of these disciplines, and developing this understanding should be an essential part of his education.

Some engineers may savour solely the technical aspects of their engineering responsibilities, for example, the development of a high functional design to meet some well-articulated need. For the environmental engineer or the engineer responsible for a project that impinges on the environment, there can be no security in technology alone. Hence, his education requires the crossing of disciplinary barriers.

In the United States and in several other of the developed countries, the opportunity to broaden engineering education has been made available in several different ways:

(1) Eliminating rigidity in course requirements and encouraging students to elect courses in other departments, schools and colleges of the university.

(2) Establishing departments that, except for a small core of faculty, are dependent upon the resources elsewhere in the university for the education of their students.

(3) Joining many departments or schools in a university to fashion a programme that draws on resources of all of them, without in any way reducing the perogatives of each unit. Such amalgamations are often called Institutes or Centres, and may be administered by a small headquarters or by staff drawn from one or more of the participating units.

(4) Establishing new, multidisciplinary departments, schools or colleges with the intention of preparing broadly-based professionals. This is generally only feasible at a relatively new institution, as otherwise the threat to existing strong departments may invite attack.

(5) Broadening the faculties of schools and colleges by including professionals and scientists from other disciplines. It is not uncommon in the United States for engineering schools to have a wide range of scientists, economists, lawyers, etc. on their faculties for participation in teaching and research programmes.

While educators in the developed countries have long felt, and still feel, that disciplinary barriers are high, in the developing countries they have been virtually insurmountable. Often modelled on the European higher educational system, but without the basic education offered by a strong secondary school system, they feature highly structured professional faculties that are completely isolated, often geographically as well as educationally. Opportunities for interdisciplinary programmes have been extremely limited. Educators from the developed countries who have served as visiting faculty in developing countries have often been frustrated by their inability to make use of resources elsewhere in the university. This isolation of faculties often results from an understandable, but unfortunate, desire for a professor to protect his position. Also, this isolation is not at all relieved by the generally part-time nature of faculty of the universities of the developing countries. Where a professor must earn most of his income outside the university, he feels hard pressed to meet his obligation to his own students and his own faculty and he is not likely to be generous with his time or resources to students or professors from other faculties of the university.

Another factor in the disciplinary isolation of universities in developing countries is that, although they are generally government-financed they are remote from the people and their problems. They tend to limit themselves to the formal education of degree candidates, and avoid using their resources for the education of the people at large or for addressing current social problems.

Because resources, needs, government institutions, educational facilities and qualified manpower vary widely over the developing world, a prescription for an educational programme in the environmental field appropriate to all countries or even all professional disciplines in one country is not feasible. A set of broad guidelines that may be useful is that resulting from a California State College (1970) workshop addressed to curriculum development in ecology and related environmental sciences, including engineering,

the conclusion of which is included in Annex F. It stresses flexibility in their own situation, and this would certainly be most appropriate for developing countries and for related professional fields as well.

One last caveat may be in order. Because water-related disease is so important and because water supply and sanitation services are so inadequate in Asia, Africa and Latin America, special efforts are required to create opportunities for large-scale training of engineers and technicians to serve in this field. Concerns for broad environmental quality should not detract from the high priority for mass training to assure control of the endemic and epidemic water-related diseases that continue as a scourge over much of the world at a time when the technology is available for their eradication.

Conclusion

Below are listed some of the actions that might well be taken by developing countries, with the aid of international agencies, in an attempt to provide the educational resources necessary for the management of the environment. Most of these actions can be undertaken simultaneously but because the development of sound institutional resources at universities is so essential to providing a foundation for other activities, and because it takes by far the greatest time, university development is given higher priority.

(1) Evaluate the educational resources of the country, particularly in higher education. Attention should also be given to specialized non-academic resources in education.

(2) Identify individuals within the educational system, or who have educational experience, who might be expected to be effective in taking initiatives to introduce environmental studies within the educational field in the country.

(3) With these individuals, determine which institutions in the country are likely to be most amenable to the initiation of environmental educational programmes.

(4) Develop a comprehensive programme for these individuals to prepare them to take educational leadership. Such a programme should be designed to the talents and needs of the individual, and possibly include formal educational programmes, but preferably informal visits of some duration to educational institutions that have environmental programmes that seem to offer the most useful models.

(5) Should it seem useful to have the assistance of educators from other countries, this is best done by engaging the resources of a university or a consortium of related universities, rather than individuals. The environmental field, or even any phase of it, is too broad to expect that any individual can do more than provide administrative assistance. The engagement of a university or consortium as a contractor to assist with the development of an environmental education programme will permit the orchestration of a wide range of resources in the effort.

(6) Inaugurate manpower studies. This should include both present and estimated future needs in both public and private sectors.

(7) Design educational programmes to meet the manpower needs. These programmes should include formal and informal education, in-service training, and public education, to be conducted wherever it is most appropriate.

A recurrent theme of this paper is that the environmental concerns of the underdeveloped and industrialized countries of the world are quite different and, in any event, the solutions must be geared to the economics of the countries concerned: for example, labour-intensive for the one and capital-intensive for the other. Therefore, in implementing the programme of educational development, there should be minimum dependence and certainly no continuing dependence on the educational resources of the industrialized world. If resources are not initially available within a country, the use of resources in the region, while perhaps less acceptable politically, is certainly to be preferred to sending individuals to institutions in the industrialized countries.

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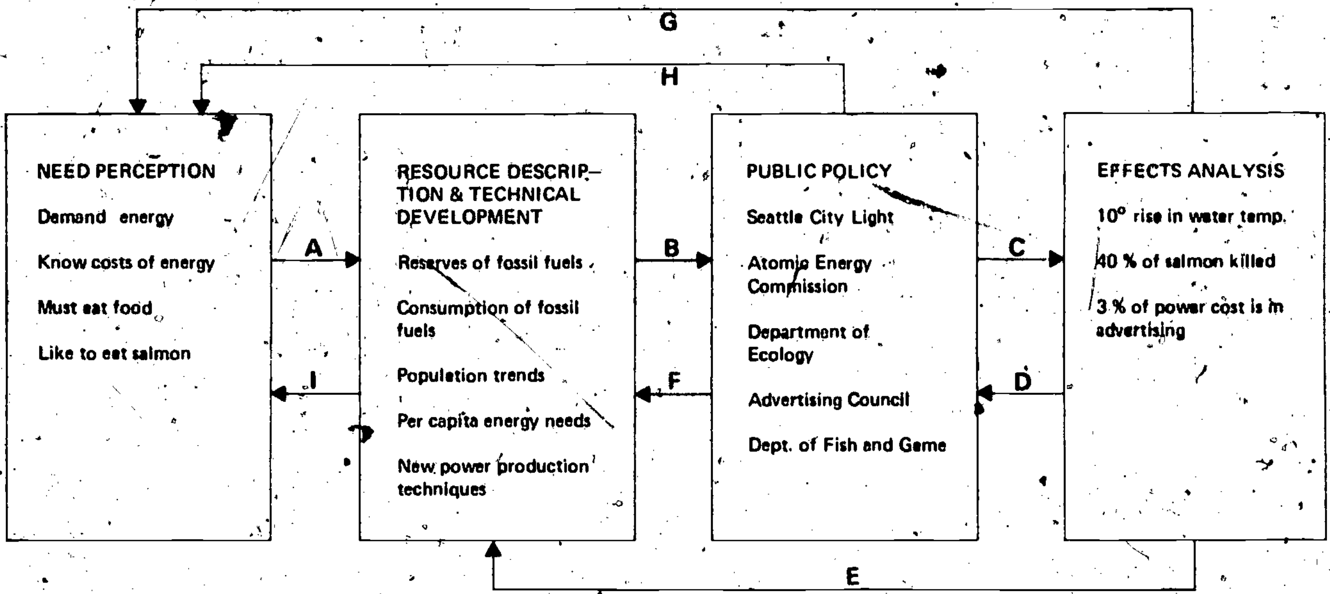
FIGURE 1 - Major health problems identified by World Health Assembly member countries and classified by numbers of identifying countries in each geographical region.

Major health concerns	Africa	Western Pacific	Southeast Asia	Americas and Caribbean	Eastern Mediterranean	Europe	Australia New Zealand Japan	Canada United States
	28	27	7	34	14	30	3	2
Malaria	19	8	3	10	9		1	
Tuberculosis	17	24	3		10	11		
Leprosy	9	11	3					
Helminthiasis	9							
Bilharziasis	9							
Diarrhoea and dysentery	9	9	7	13	7			
Filariasis		8	3					
Deficiencies in organization and administration	6		1	5	7	12		1
Trypanosomiasis	6							
Onchocerciasis	5							
Venereal disease	6	12		13		9	1	2
Malnutrition	6	6	3	16	3			
Environmental, deficiencies	5	11	7	13		11	3	
Smallpox	3		2					
Cholera (including el Tor)		6	2					
Meningitis	1-2							
Yaws	1-2							
Enteric fevers	1-2							
Trachoma	1-2		2		6		1	
Infectious hepatitis	1-2					11		1
Accidents	1-2					6	3	2
Respiratory virus diseases		5				11		
Population pressure		5	3					
Cancer			2		3	9	3	2
Chronic degenerative disease				4	3	9	3	2
Alcoholism				4			1	
Movement of people					5			
Urban congestion					1			
Vascular disease of central nervous system							1	
Mental disorders				4		6	3	1
Narcotics							1	
Dental health		4					1	2
Indigenous population							2	
Aged and chronically ill								1
School health								1
Handicapped								1
Manpower								1

Regional profiles of health problems. Developed from a questionnaire reported by the World Health Organization in Third Report on the World Health Situation, 1961-1964, No. 155 (Geneva, 1967), pp. 28-35. Some data were taken from a prepublication mimeographed document of the same title. The figure at the top of each column indicates the number of countries reporting. Circles and figures in columns indicate the number of countries listing the particular health problem as a major concern, a black circle indicates regional consensus that the problem was one of the most important. The vertical line arbitrarily separates less developed from more developed regions. The horizontal line separates diseases of greatest concern to less developed regions from those of greatest concern to more developed regions.

Source: Bryant J., (Health and the Developing World)
Cornell University Press, 1969, p. 30.

Fig. 2. FRAMEWORK OF ENVIRONMENTAL ENGINEERING RESEARCH QUESTIONS



DIRECT QUESTIONS

A. Given a desire for power - what section of the material universe constitutes a power resource (fossil, fuels, nuclear fuels, water, etc.)?

B. Given that a certain type of fuel (nuclear) is desirable for use in power production - what type of management procedure (AEC policies) should be implemented to regular its use?

C. What effect will the level of nuclear-power development, as anticipated by AEC, have on man and his physical and mental environment?

FEEDBACK QUESTIONS

D. and G. Both loops represent threshold phenomena. Threshold levels of effect are functions of the sensitivity and accuracy of environmental-quality indicators and communications procedures. Example of loop D: How can feedback time between observed effect (temperature or radiation levels) and policy adjustment be minimized? Example of loop G: In cases of large-effect levels (temperature or radiation levels that are large and cannot be reduced by policy decisions) the perception of need for power must be re-evaluated.

E. Does a 10° rise in river-water temperature as a result of power-plant operation constitute a new source of low-grade thermal power? Are new resources created as a result of effects?

F. Does the grant-funding policy of a major regulatory agency affect our level of understanding regarding material resources, their quality, quantity and characteristics?

H. How does advertisement by the power supplier affect our perception of need for power? Does regulation of information on radiation levels by AEC affect our perception of the benefits of nuclear power?

I. To what extent does new technological development (nuclear fusion) affect our perception of need for power?

ANNEX A

CLASSROOM SCHEDULE AS OF 20 NOVEMBER 1972

Date	Lecturer	Morning session	Afternoon session
		INTRODUCTION	
22.1.1973	Professor Stern Mr. Aizenstat Mr. Hinote Mr. Long	IPEAID Programme	Env. problem (Professor Chanlett)
23.1.1973	Professor Chanlett	Env. problem	Env. problem
		WATER AND WASTE WATER	
24.1.1973	Dr. Okun	Introduction: water env. Quality and quantity consideration, measurement/monitoring	Discussion
25.1.1973	Dr. Okun	Water costs, use, reuse	Discussion
26.1.1973	Dr. Little	Nature of water pollution	Field trip-UNCWRG
29.1.1973	Dr. Francisco	Effects of pollutants on life	Discussion
30.1.1973	Professor Barnes	Measurement/monitoring of pollutants	Discussion
31.1.1973	Professor Barnes	Industrial waste surveys	Discussion
1.2.1973	Dr. Busch	Control technology for industrial water/wastewater	Case study
2.2.1973	Dr. Baker	Taste and odour problems	Discussion
		AIR POLLUTION	
5.2.1973	Professor Stern	Introduction: Air env., air pollutants	Discussion
6.2.1973	Dr. Dicke (Mr. Zeller)	Transport and diffusion of pollutants	Discussion
7.2.1973	Professor Ripperton	Effects of air pollution on life (plants, animals, humans) and on property	Discussion
8.2.1973	Dr. Jefferies	Measurement/monitoring of air pollutants	Field trip-NERC, N.C.
9.2.1973	Mr. Hemingway	Control technology for particulate air pollutants	Discussion
12.2.1973	Mr. Sickles	Control technology for gaseous air pollutants	Discussion
		LAND AND PEOPLE	
13.2.1973	Dr. Cassel	Effects of industrial development on community health	Discussion

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Date	Lecturer	Morning session	Afternoon session
14. 2. 1973	Professor Chanlett	Physical-energy exacerbations including noise, heat, ionizing-radiation, non-ionizing radiation	Discussion
15. 2. 1973	Dr. Miernyk	Effects of industrial development on community noise, transportation, school systems, recreational facilities and tourist attractions	Discussion
16. 2. 1973	Dr. Vesilind	Solid waste; disposal and recycling (recovery and reuse)	Discussion
		INDUSTRIAL HYGIENE	
19. 2. 1973	Dr. Fraser	Introduction: occupational disease	Discussion
20. 2. 1973	Professor Ferris	Standards for plant environment	Discussion
21. 2. 1973	Mr. Wrenn	Sampling methods	Discussion
22. 2. 1973	Professor Burgess	Control methods	Discussion
23. 2. 1973	Dr. Goldwater	Model industrial hygiene programme	Case study
		ORGANIZATION FOR ENVIRONMENTAL CONTROL	
26. 2. 1973	Professor Heath	Legislation, regulations standards	Discussion
27. 2. 1973	Professor McJunkin	Environmental audits	Discussion
28. 2. 1973	Mr. Strelaw	Economical, political and social restraints on environmental protection	Discussion
1. 3. 1973	Dr. Okun Dr. Schueneman	Administrative, legal, organizational development in United States and in Europe	Discussion
2. 3. 1973	Dr. Fitzpatrick	Industrial development for the environmental field	Discussion

ANNEX B

UNIVERSITY OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING
SCHOOL OF PUBLIC HEALTH

AID-ENGINEERS ENVIRONMENTAL PROGRAM
Course outline

Date	Day	Period	Professor	Subject
6.8.1973	M	9.00-10.20	Chanlett	Introduction and overview
		10.30-11.50	Lauria	Economic interpretation of pollution
		1.30-2.30	McJunkin	Environmental assessment - institutional framework
		2.45-4.00	Chanlett	Environmental assessment - institutional framework
7.8.1973	Tu	9.00-10.20	Chanlett	Solid wastes
		10.30-11.50	Lauria	Wastewater characteristics and effects
		1.30-2.30	Heath	Legal aspects of environmental management and protection
		2.45-4.00	Campbell	Legal aspects of environmental management and protection
		6.30		Cocktail reception - home of Mr. & Mrs. D. T. Lauria
8.8.1973	W	9.00-10.20	Chanlett	Vector control
		10.30-11.50	Lauria	Wastewater treatment
		1.30-2.30	Apple	Environmental effects of agricultural development
		2.45-4.00	Rigney	Environmental effects of agricultural development
9.8.1973	Th	8.00-5.00	Staff	Field trip
10.8.1973	F	9.00-10.20	Shy	Economic development and health
		10.30-11.50	McJunkin	Waterborne diseases
		1.30-2.30	Lamb	Environmental impact of industrial development
		2.45-4.00	Lauria	Environmental impact of industrial development
13.8.1973	M	9.00-10.20	Chanlett	Air environment - occupational
		10.30-11.50	Patrick	Social impact of economic development
		1.30-2.30		Preparation of environmental impact statements
		2.45-4.00	Lemmon	Preparation of environmental impact statements
14.8.1973	Tu	9.00-10.20	Chanlett	Air environment - community
		10.30-11.50	Weiss	Environmental impact of electric power generation
		1.30-2.30	West	Environmental impact statement - water resources
		2.45-4.00	Jackson	Environmental impact statement - water resources
15.8.1973	W	9.00-10.20	Chanlett	Radiation protection
		10.30-11.50	Lauria	Water quality standards and enforcement
		1.30-2.30	White	Environmental impact statement - transportation
		2.45-4.00	Lathrop	Environmental impact statement - transportation
		6.30		Reception - Carolina Inn
		7.30		Dinner - Mr. Jimmy Wallace
16.8.1973	Th	9.00-10.20	Chanlett	Thermal pollution
		10.30-11.50	Lauria	Environmental economics
		1.30-4.00	Staff	Participant presentations
17.8.1973	F	9.00-10.20	Chanlett	Noise and non-ionizing radiation
		10.30-11.50	Lauria	Water supply in developing countries
		1.30-2.30	Staff	Course review and summary
		2.30	Staff	Closing ceremonies

ANNEX C

PRELIMINARY PROGRAMME

ENVIRONMENTAL PROTECTION CONFERENCE FOR EDUCATORS

3-4 May 1973

Thursday, 3 May 1973

8.00 a.m.-8.30 a.m.	Registration	
8.30 a.m.-9.15 a.m.	Welcome and conference goals	Dr. Daniel Okun
9.15 a.m.-10.00 a.m.	The origins of environmental issues	Professor Emil Chanlett
10.00 a.m.-10.15 a.m.	Break	
10.15 a.m.-10.45 a.m.	Ecological balances	Dr. Edward Kuenzler
10.45 a.m.-11.15 a.m.	Human health and well-being	Dr. Mario Battigelli
11.15 a.m.-11.45 a.m.	Environmental awareness vs. environmental technology	Dr. C. Ritchie Bell
11.45 a.m.-1.00 p.m.	Lunch	
1.00 p.m.-2.00 p.m.	Agents of stress	Dr. Daniel Okun
2.00 p.m.-3.00 p.m.	Specific sources and impacts Water Air	 Dr. James Lamb, III Professor Arthur C. Stern
3.00 p.m.-3.15 p.m.	Break	
3.15 p.m.-4.15 p.m.	Specific sources and impacts (continued) Land Occupational setting	 Dr. Edward Kaiser Dr. Parker Reist
4.15 p.m.-5.00 p.m.	Legal, political and social aspects	Professor Milton Heath
5.00 p.m.-5.30 p.m.	Governmental agency programmes	Professor David Howells

Friday, 4 May 1973

8.00 a.m.-10.00 a.m.	Panel - Environmental protection Education needs and resources, agency viewpoints	
	Moderator	Professor David Howells
	North Carolina Office of Water and Air Resources Air Quality Division Water Quality Division	
	State Board of Health Sanitary Engineering Division Occupational Health Section	
	State Department of Labour	
	Environmental Protection Agency	
	National Institute of Occupation Safety and Health	

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10.00 a.m.-10.15 a.m.	Break
10.15 a.m.-10.30 a.m.	Special interest session procedures
10.30 a.m.-12.00 noon	Concurrent sessions for special interest groups (discussion of needs, resources, and action by institutions) Individual curriculum areas for discussion in the 4 or 5 special interest sessions will be designated on the basis of expressed interests by participating institutions. For example: A. General environmental science education B. Teacher education curriculum C. Environmental health technology curriculum D. Environmental engineering technology curriculum E. Occupational safety and health curriculum
12.00 noon-1.00 p.m.	Lunch
1.00 p.m.-3.30 p.m.	Concurrent sessions for special interest groups (continued)
3.30 p.m.-3.45 p.m.	Break
3.45 p.m.-5.30 p.m.	Plenary session A. Presentation and discussion of special interest groups reports B. Summary and discussion of proposed post-conference actions

Preparation

Each participant is requested to bring with him to the conference the following:

1. A listing of courses in environmental protection now offered at his institution.
2. A description of any formal curriculum relevant to environmental protection offered at his institution.
3. A listing or description of current interests in environmental protection course or curriculum development for his institution.
4. A listing of resources or assistance available from his institution to other institutions engaged in environmental curriculum development (i.e. specific experience, unique expertise, etc.).

ANNEX D

DEPARTMENT OF ENVIRONMENTAL SCIENCES AND
ENGINEERING SCHOOL OF PUBLIC HEALTH

ENVR 101: Elements of Environmental Health, 2 Credits, Spring Semester 1974

Plan of instruction: Lectures and seminars, 10.00-11.00, TTh.

Textbook: None required
Recommended: Environmental Protection, by Professor Emil T. Chanlett

Instructor: Dr. Stanley J. Weidenkopf

January	10	Th	Introduction (SJW)
	15	T	Nature of Env. Problems (SJW)
	17	Th	Nature of Env. Problems (SJW)
	22	T	Air Pollution and Control (ACS)
	24	Th	Air Pollution and Control
	29	T	Air Pollution and Control
	31	Th	Air Pollution and Control
February	5	T	Land Pollution and Disposal of Solid Wastes (SJW)
	7	Th	Land Pollution and Disposal of Solid Wastes
	12	T	Land Pollution and Disposal of Solid Wastes
	14	Th	Radiological Hygiene (DGW)
	19	T	Radiological Hygiene
	21	Th	Radiological Hygiene
	26	T	Radiological Hygiene
	28	Th	Mid-Term Exam (SJW)
March	5	T	Water, Sources and Treatment (SJW)
	7	Th	Water, Sources and Treatment (SJW)
	19	T	Waste Water Treatment (DEF)
	21	Th	Waste Water Treatment (DEF)
	26	T	Field Trip (SJW & DEF)
	28	Th	Community Noise (AGT)
April	2	T	Community Noise
	4	Th	Industrial Hygiene (PR)
	9	T	Industrial Hygiene
	11	Th	Industrial Hygiene
	16	T	Seminar
	18	Th	Seminar
	23	T	Seminar
	25	Th	Seminar
29 April-8 May			Final Exams

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SPRING 1974

MAN AND HIS ENVIRONMENT

ENVR 111

January	9	Introduction
	11	Health and disease factors in the environment
	14	Health hazards from biological contaminants
	16	Health hazards from chemical agents
	18	Health hazards from physical agents
	21	Toxicology and the consumer
	23	Toxicology and the consumer (continued)
	25	Environmental stress factors (psycho., social stimuli, noise, overcrowding)
	28	Environmental stress factors (continued)
	30	Current problems in environmental perception and behaviour
February	1	Economic approaches to achieving environmental quality
	4	(continued)
	6	(continued)
	8	Review and quiz
	11	Ecology in relation to the environment
	13	Ecology in relation to the environment (continued)
	15	The concept of technology assessment
	18	NEPA and environmental impact
	20	Indicators and measurement of environmental hazard and environmental quality
	22	(continued)
	25	Environment and public policy
	27	(continued)
March	1	Environmental management
	4	(continued)
	6	(continued)
	8	Review and quiz
	18	Current issues in environmental management
	20	Land use aspects of environmental management
	22	Land use (continued)
	25	Radiation standards
	27	Decision-making in air quality control
	29	(continued)
April	1	Environmental protection aspects of housing and the residential environment
	3	Lead poisoning in children in the urban environment
	5	Population, food resources and the environment
	8	(continued)
	10	Energy resources and the environment
	12	(continued)
	15	Environmental protection problems in the less developed countries
	17	(continued)
	19	International organization for environmental protection
	22	Public participation in environmental decision-making
	24	Course review

VII. CONCLUSION

In the course of the two-day meeting of some 50 participants, many ideas, concepts and proposals for action were put forth for discussion and examination. The workshop groups served to distill a number of conclusions and generalizations. At the risk of overlooking significant points, certain themes appeared early in the meeting's discussions and were given form in at least one of the workshop group reports. These themes are summarized below.

Model curricula. No uniform, model curricula in ecology and related environmental sciences should be applied throughout the California State Colleges. Each college has the responsibility to assess its own strengths, its potential and the needs of its students as it develops new curricula or adapts existing courses and programmes emphasizing environmental concerns. The experiences of colleges within the system and outside should, however, be noted; in this context, meetings such as the Invitational Workshop are most useful.

Specializations by college. Each college should seek to develop environmental studies focuses appropriate to its locale, student body, and resources. No college should seek to offer all possible approaches to the study of ecology. There should be complementary programmes from one college to the next, rather than duplicatory ones. College planning and programme development should take place with reference to other colleges in the system.

Articulation with community colleges. The majority of today's students in the State Colleges have begun their collegiate work in one of the State's many community colleges. Curriculum development in environmental studies must therefore provide for ease of transfer. Further, development of certain kinds of programmes may require close co-operation with community colleges.

Cautious development of specialized programmes. A common theme throughout the course of the meeting was that the problems of the environment are so diverse, and the solutions so tentative, that training of large numbers of highly specialized persons is inappropriate. Students in the sciences, engineering, technology as well as the social sciences are best served by a substantial environmental component to their education to assist them in adapting to the demands of the future. Doubtless many persons in the years to come will play substantial rôles, in their work careers and as members of the general public, in attempting to maintain and improve the environment. Such activities will be across a wide spectrum and will not be restricted to a limited number of occupational classifications. This suggests that in developing responses to the environmental problems, colleges should construct curriculum which can assist in the education of persons who can fulfil a number of different responsibilities.

Emphasis on the environment throughout curriculum. Workshop participants agreed generally on the need for all students to engage in studies of the environment and its problems. All appropriate curricula should include attention to the study of the environment. Single-focus courses do not appear appropriate as a part of general education requirements; rather, a re-shaping of courses and programmes in a variety of disciplines is called for.

Interdisciplinary studies. The education of students who are concerned with the problems of the environment and capable of contributing to their solutions cuts across many disciplines. The solutions to the problems of the environment, as reflected by workshop participants, will require not only scientific and technical skills, but political and economic expertise as well. The scientist or technologist who seeks a solution to a problem of the environment must understand the economic and political realities of the problem. The scientist in general, many participants pointed out, must realize the social and environmental impact new scientific and technical developments may have. The government leader and the industrial manager must be conversant with the scientific and technical knowledge of the environment and be aware of the kinds of specialists needed to attack environmental problems. Thus the need for interdisciplinary or multidisciplinary environmental studies was recognized by most participants; however, the problems of the collegiate, departmental structure were often noted as inhibiting the development of needed courses and programmes.

Problem-oriented instruction. A common theme in discussions was the value of using a specific environmental problem upon which students and faculty can concentrate as a desirable pedagogical technique. Similarly, the need for work experience in an environmental problem area and individual or group research was stressed. While a problem-oriented curriculum and work experience are considered useful in many subject fields, their particular appropriateness in environmental studies was stressed.

Terminology. "Ecology", "environment", "ecological studies" and "environmental studies" and "sciences" are among the various terms applied to academic programmes concerned with aspects of the environment. Based on workshop discussions and the existing literature concerning academic programmes in the general subject area, the term "environmental studies" appears most useful as a general terminology broadly applicable to a variety of programmes. "Ecology" as a term for academic degrees and programmes is most generally understood as applying to the science of ecology within the biological sciences. Environmental science and environmental technology have their appropriate usages but do not clearly connote specific degree or other academic programmes.

CONSIDERATIONS ON THE ORGANIZATION OF TRAINING IN ENVIRONMENTAL ENGINEERING

by

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TABLE OF CONTENTS

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1. INTRODUCTION

Environmental protection is, from the point of view of both science and engineering, a typical interdiscipline subject. This entails several problems not only in determining the scope and organization of training, but also in adoption of explicit terminology.

According to the National Science Board[1], "Environmental science is conceived as the system of air, land, water, energy and life that surround man. It includes all sciences directed to the system-level of understanding of the environment, drawing especially on such disciplines as meteorology, geophysics, oceanography, and ecology, and utilizing to the fullest the knowledge and techniques developed in such fields as physics, chemistry, biology, mathematics and engineering".

The World Health Organization is preparing a World Directory of Institutions for the Training of Environmental Health Personnel(2). After stating that "Environmental health" is not yet a clearly defined field of study, there follows a list of relevant study subjects:

Water resources: Water quality. Water and waste water treatment. Domestic water supply. Domestic water disposal. Industrial water supply. Industrial water disposal. Limnology. Water pollution. Hydrology.

Air resources: Meteorology and climatology. Chemistry and biology of air. Air pollution control.

Public health: Vector control. Industrial and occupational health. Air hygiene. Parasitology. Food sanitation and hygiene. Rural sanitation. Toxicology. Public health administration. Radiological protection. Health education.

Land use and shelter: Urban and land use planning. Solid waste collection and management. Housing. Recreation. Noise control.

Management: Planning resources systems. Public development economics. Public and business administration.

General: System analysis. Applied statistics. Human ecology. Applied biology. Epidemiology. Management. Microbiology.

The above list, besides enumerating the disciplines of engineering sciences, also exemplifies the objectives of engineering in environmental protection.

In the range of technical sciences, "sanitary engineering" represents a specialization of long-term tradition. In the course of its development, the scope of that discipline has been time and again broadened to include new areas covering, in growing measure, matters relative to environmental protection in its extensive understanding. For this reason, apart from the term of "sanitary engineering" one encounters sometimes the term of "environmental health engineering".

Alongside with sanitary engineering and environmental health engineering, there exist, in the area of environmental sciences, various other disciplines qualifying for the degree of Master of Science or its equivalent, such as e. g. Environmental Engineering, Environmental Protection, Environmental Management, Environmental Chemistry, Water Resources Engineering, Air Pollution and several others. The scope of those specializations may be evaluated only on the basis of teaching programmes which, depending on the respective country, can be considerably diverse.

The above-mentioned examples are sufficient to show that the nomenclature of engineering disciplines relative to environmental protection and management is far from being explicit. It seems, however, that further discussion on the matter would be unproductive, since one may assume that the objectives of technology and the tasks of engineers in environmental protection and management can be defined quite explicitly. From the point of view of the training of engineers in that range, it is most essential, therefore, to answer the following questions:

(1) Is it possible, within an average five-year course of post-secondary university level education, to achieve the qualification of a one-type engineer to master all problems in the area of environmental protection and management, or is it imperative to conduct separate training for various engineering specialization?

(2) Is it possible to determine some basic specializations for environmental engineers to be recommended universally, independent of the development level of respective countries?

(3) Is it possible to determine some optimum recommended common teaching disciplines for all specialization lines of environmental engineers?

(4) In what measure and what scale should be promoted post-graduate training - national, regional, international?

While the replies to these questions will certainly be subject to a discussion of the Expert Group, some suggestions relative to the matter will ensue in a further part of this paper.

2. PRESENT CONDITION OF TRAINING ORGANIZATION

2.1 Introduction

The organization of academic education in respective countries having been described in detail in the Unesco publications(3)(4), we are here limiting ourselves to no more than several statements necessary in view of further explicity.

Notwithstanding considerable difference in the organization of the university level school systems in respective countries, certain regularities exist in this area. The starting level for academic education is in completing of primary and secondary education lasting in all 11-13 years. Higher studies are undertaken at the age of 17-19 and last 4-6 years in the case of technical sciences. The period of academic training is often divided into two steps of which the first, taking 2-4 years, ends with awarding a certificate of the 1st degree (Diplôme universitaire de premier cycle, Ingénieur, Bachelor's degree). The following second step training,

lasting, 1-2 years, ends with awarding a certificate of higher degree (Diplôme, Diplôme Ingénieur, Master's Degree, Maîtrise). Numerous university level technical schools conduct third-step training, ending with the award of a Doctor's title (Docteur de spécialité, Doctor's degree).

Irrespective of studies continued within an overall training cycle, there are organized some post-graduation training courses lasting 1-2 years, the completing of which usually ends with vocational qualifications for a particular field of specialization.

The requirements to be met by environmental protection engineers justify the statement that one may talk only of training at a level corresponding to the award of a Master's degree, or still higher. In further discussing the organization of training in environmental protection, attention will be given mostly to the second step of university level education. It is emphasized that when talking of environmental engineers, we shall always understand the term as corresponding to a completed second degree university level education.

2.2 Complete cycle of engineers' training

The WHO document(5) published in 1971, presents a survey of programmes for technical training in environmental protection, as provided by the universities of Sao Paulo (Brazil), Valle, Cali (Colombia), Calcutta (India), Bangkok (Thailand), Kyoto (Japan), California, Berkeley (United States of America), North Carolina, Chapel Hill (United States of America), Kuibyshev, Moscow (USSR), and Naples (Italy). Moreover, use was made of the detailed programmes of training in 1971-1972 at the universitis of: Pennsylvania(6), Standford(7), California Institute of Technology(8), North Carolina at Chapel Hill(9), Massachusetts Institute of Technology(10), as also at all the academic level technical schools in Poland. Although the presented material is somewhat incomplete, it can nevertheless serve as basis for the formulation of some general conclusions relative to the present condition of training organizations.

It may be assumed that, within the five-year training cycle, students have a total of about 4,000 occupation hours (lectures, laboratory, exercises). The entire training programme may be divided, most broadly, into four subject groups: human sciences, fundamental sciences, engineering sciences and specialization disciplines. One may, moreover, assume that in the respective subject groups the scope of training will be as follows:

Human sciences - economics, philosophy, political sciences, sociology, foreign languages, etc.

Fundamental sciences - mathematics, physics, chemistry, biology.

Engineering sciences - working out of projects and industrial design, electrotechnics and electronics, fluid and solid body mechanics, thermodynamics, geodesy, instrumentation and measurement.

Specialistic subjects are, obviously, different for the respective fields of study.

The time ratio afforded to training in the respective subject groups varies widely depending on the country and university; in general, however, it is comprised within limits presented in Table 1.

Table 1

Discipline	Training time per cent of total
Human sciences	10-20%
Fundamental sciences	20-30%
Engineering sciences	15-25%
Specialization disciplines	20-40%

Primarily, the training of engineers in disciplines relative to environmental protection has been developed within civil engineering and sanitary engineering departments. Main stress was then laid on matters of water supply, domestic and wastewater treatment, waste disposal and heating and ventilation. An example of such specialization is provided by the training programme in sanitary engineering at the Sao Paulo University(5), presented in Table 2 - see Annex I.

In recent years, the number of specializations in environmental protection has considerably increased, particularly in the United States. Universities permit following such specialization lines as: water resources, water quality management, environmental chemistry and biology, industrial hygiene, air pollution, environmental protection, environmental management, environmental engineering, radiological hygiene.

The essential changes in training programmes mainly consist, however, not on broadening the range of possible specializations, but, mostly, on the overall approach to environmental protection and on the successively increasing introduction of system analysis elements.

The United States universities assume a principle of far going individual differentiation of training programmes, enabling the students to adopt flexible sets of programmes, providing that the weekly number of effective occupation hours amounts to 20-30 hours. Illustrative programmes of specialization training in water quality management, air pollution, and environmental management, afforded at the University of North Carolina at Chapel Hill(9), are presented in Tables 3, 4 and 5 - see Annex I.

The advantage of the quoted programmes lies in their interdiscipline characteristic and flexibility, enabling one to choose sets in various variants of study courses. Carrying through of such type of training organization is, however, possible only in big universities having a numerous teaching staff, as well as an extensive research equipment.

In Poland, training in environmental protection engineering is conducted by five university level technical schools, enabling specialization in: water management and hydrology, air pollution control and sanitary engineering. An illustrative programme of training in air pollution control conducted at the Warsaw Institute of

Technology (Politechnika Warszawska) is presented in Table 6 - see Annex I.

It seems that the above quoted examples of study programmes enable a clear enough view of the existing organization and scope of environmental engineers' training. They may also serve as basis in the formulation of conclusions relative to the recommendation of training systems.

2.3 Post-graduation training courses

In times of rapid changes in the technique and methods of approach to environmental protection matters, an essential part of the engineers' training is played by post-graduation courses. Among those organized in this area, one may distinguish:

(1) Specialization training courses taking at least a full academic year.

(2) Short-term 1-2 months vocational training courses.

Courses of both types are now conducted on a national, as well as on an international scale. The organization and topics are, naturally, considerably diverse in respective cases. It is worth while, however, to take note of the illustrative programmes of training sponsored by WHO (Table 7 - see Annex I) at the Mohammed V University, Rabat, Morocco[11].

2.4 Final considerations

Evaluating, on the whole, the present condition of engineers' training in environmental protection, it is possible to observe a considerable diversity of schemes and trends not only within particular countries, but even within particular teaching institutions. In the majority of cases, however, training in environmental protection is being developed through evolution of the traditional and narrowly comprehended training in the field of sanitary engineering. One may take the risk of concluding that training in the specialized discipline of environmental protection is in general, particularly as regards the matter of training, severely belated in relation to the rapidly growing needs in that area.

3. PROPOSED DEVELOPMENT

3.1 General remarks

The human environment is not a collection of isolated events and phenomena, but rather a vast, integral, mutually interacting system embracing, at global scale, the whole world. In this regard, any action undertaken to the benefit of particular areas or population groups may not be estimated as absolutely good or evil without first taking into consideration its possible effects produced in other areas or population groups. Simultaneously, any action leading at present to seemingly positive effects may have future detrimental or even catastrophic consequences. This aspect of problems relative to environmental protection necessitates the assuming of rather essential modification in the way of thinking and the mentality not only of experts responsible for environmental protection, but, virtually, of entire human societies. With this background, one may formulate:

Recommendation 1: It is necessary to introduce, into the tuition programmes of all levels, from primary to university, some elementary concentration not only on the imperative need of environmental protection, but similarly on the composite nature and interdependence of all phenomena involved.

Problems of environmental protection reduce, in brief, to limitation of raw materials use and to limitation of waste production. Assuming, even, the prospect of essential changes in engineering science and technology, one must, none the less, reckon, in a foreseeable future, with constant growth of raw materials use and constant growth of waste production. Possible solutions of the problem must, therefore, be sought not only through engineering, but likewise in modfying the life patterns of whole societies, and particularly those of highly developed countries. It seems that satisfactory results in environmental protection cannot be expected before there are essential changes in life patterns, consisting on reducing trends in the unrestricted consumption of material goods, to the advantage of trends towards profiting of cultural values. Important rôles are here to be played by adequate education and training, and, in this regard, one may suggest the following:

Recommendation 2: It is necessary, in the tuition programmes of all levels, from primary to academic, to place emphasis on elements able to lead towards modifying man's mentality in a sense where aiming at increased consumption of material goods would be replaced by aiming at increased cultural values.

To achieve satisfying results in environmental protection, mutual co-operation of engineers, economists, physicians, biologists, sociologists, etc., is a necessity. Such co-operation, however, may be possible only if all those vocational groups use the same "language". Moreover, the respective groups should have substantial knowledge of the scope of interaction, and of the actual possibilities of effectively influencing the process of environmental transformation.

Recommendation 3: It is necessary, in the graduate tuition programmes of all specialization disciplines relative to environmental protection, to introduce elements enabling mutual exchange of information and mutual understanding among the various vocational groups.

In effect, the activities of any engineer and particularly those of an environmental engineer, always lead in consequence to some changes, both social and economic. For this reason, human and social sciences should have a growing part in the education of environmental engineers. The above postulation has been developed and justified in E. J. Holstein's work[5]. On this basis, one may formulate the following:

Recommendation 4: The engineer of tomorrow must have, in the range of social and human sciences, a knowledge sufficient to enable application of his technical skill in the solution

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of important social problems and thus to contribute practically to social progress.

The essential rôle of mathematics in the training of engineers is gaining more and more esteem in universal opinion(5). In environmental engineering, where it is fundamentally necessary to deal with composite problems including, moreover, multiple variables and requiring routine use of computer techniques, the rôle of mathematics is still more essential. The language of mathematics, being universal, facilitates comprehension among those specialized in various fields. Considering the above statement as obvious and not requiring justification, one may formulate the following:

Recommendation 5: It is necessary, in the programmes of environmental engineers' training, to emphasize training in mathematics as of a science enabling both adequate formulation and solution of the numerous tasks relative to environmental protection.

3.2 Environmental engineering as science of systems analysis

The general opinion now prevailing is that the only way towards solving of engineering problems in environmental protection is in the adoption of the systems analysis principles. In Mr. Thompson's paper presented at the Unesco Expert Meeting(12) it is stated: "Environmental problems must be conceived in the scope of ever larger physical systems. The effects of the engineer of developing technologies must be addressed to broader systems as must also be the analysis that would make best use of present and developing technologies".

The WHO Experts Report(13) states, in turn: "... methods applied today by engineering and design services for solving of environmental hygiene problems are totally different from those used earlier. To draw plans, to proceed in research and to work out the equipment, material and services, it is now necessary to base on the notion of 'systems' implying use of analytical methods in solving of problems relative to the multiple variables to be accounted for in the distribution and utilization of resources".

One must, moreover, point out that systems analysis is at present the sole available method to adopt decisions in the scope of technology with full account taken of the various economical, sociological and ecological factors. Systems analysis provides, equally, an excellent base of common understanding among those specialized in various fields. It seems, therefore, fully justifiable to use systems analysis as an initial basis in the training of environmental engineers.

In the classical approach, the way of proceeding in system analysis may be divided into four steps(5):

(1) Working out of a model compatible with the existing techniques of mathematics and information, proper account being taken of the system's principal mechanisms.

(2) Definition of an objective function enabling classification, in preferential order, of all conceivable designs and plans.

(3) Empirical estimation of the model's parameters in the situation under consideration.

(4) Solution of the model using mathematical and computer techniques. The problem consists of finding, for the variables intervening in decisions or even in the concept, of values maximizing or, more generally, optimizing the objective function.

Overall utilization of the classical methods of systems analysis in environmental protection is still meeting with considerable difficulties. First of all, it is sometimes impossible to establish the objective function because of the large number of different parameters of the system. Today, it is difficult to include in the objective function the effect of pollutants on man's health or on nature. Moreover, the numerous attempts at developing of mathematical models describing, in composite, all the environmental elements have not so far brought satisfactory results.

On the other hand, however, real possibilities already exist to solve optimization problems of some of the environmental sub-systems, as e.g. water management, or air pollutant's circulation in the atmosphere. Irrespective of this, even partial utilization of systems analysis principles, may lead to most appreciable results in solution of problems relative to environmental protection.

All the above advantages of systems analysis completely justify its acceptance as a basis in the training of environmental engineers, entitling us to formulate the following:

Thesis 1: The principles of systems analysis should be assumed as a basis in the training of environmental engineers.

3.3 Engineering specializations in environmental protection

The objectives of engineering and the tasks of engineers have been often discussed and quoted at various conferences and meetings, national and international. At the Unesco Expert Meeting on Environmental Engineering(14), the objectives of engineering and the tasks of engineers were defined as follows: "The engineer is particularly concerned that the economic and social considerations which guide this selection of technological solutions for decision-making, and that the consequences of the technological solutions found be optimized to the welfare of man. It follows that environmental engineering can be defined as the exercise of the engineering disciplines taking into full account the full environmental consequences of the proposed solutions in deference to the expressed socio-economic needs leading to engineering artifacts".

In turn, the WHO Expert Committee(13) states that the environmental hygiene engineer "must be able to advise on: localization of agglomerations and big thermal power plants; problems of the transformation of fertile land areas into trade and residential zones, type of waste disposal system to be provided for the determined industrial or agricultural enterprise or branch of activity; choice of propulsion mode to be adopted for common transport vehicles; utilization of

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local resp. of imported materials for housing construction, etc. He must have a knowledge of all factors to be accounted for in: management of water supply systems; liquid and solid waste disposal; hygiene of food and of its storing compartments; prevention of occupational diseases and accidents; reduction of air, water and soil pollution; vector control, etc.".

In a report of the WHO Expert Committee(13), the term of "environmental health engineering" is defined as follows: "application of engineering principles to the control, modification, or adaptation of the physical, chemical and biological factors on the environment in the interest of man's health, comfort and social well-being".

According to the latest version worked out by WHO(14), the definition of a sanitary engineer reads: "The sanitary engineer is an engineer having acquired appropriate training (preferably post-graduate or third degree level) enabling him to apply technological principles in:

(i) the prevention, control and handling of environmental factors influencing man's physical, mental and social health and well-being;

(ii) works and procedures necessary for maintenance and improvement of the human environment quality level, in view to ensure man's health, comfort and efficiency.

He performs tasks similar to those of a civil, a chemical, or a mechanical engineer, while, however, concentrating his performance on planning, calculation, design, operation, maintenance and control of specialized installations, such as, for example, equipment used for the control of air, of soil and of water resources quality, of human environment and working places, and particularly of drinking water installations, of solid and fluid waste disposal, of vector control, of habitat hygiene, noise control, disposal of nocive gases and of industrial waste; he evaluates, finally, the output of such installations.

In collaboration with public health doctors and other scientific personnel, he investigates environmental factors, he organizes and supervises measurement and survey programmes of man's environment quality; he contributes to the working out of reports relative to the impact of development and construction programmes on the environment; he undertakes research and investigations, participates in the working out of hygiene standards applicable in urban and regional planning and in evaluation of the precision level and efficacy of programmes and of measures assumed in view of protecting man's health and well-being.

He plans, directs and co-ordinates the environmental hygiene programmes carried through public health institutions and other government departments, by autonomous public type units, and by private organizations and enterprise; he organizes research and investigations relative to the economical, financial and legal aspects of environmental hygiene".

In all WHO recommendations and definitions, main stress is, obviously, laid on those items in environmental protection which affect directly man's health. In a broader sense, environmental protection means the protection of the entire natural environment and the proper management of natural resources. Attention should therefore be given to the following range of engineers' activities relative to environmental protection, important alongside with those listed earlier:

(1) working out and industrial scale implementation of new techniques and technological proceedings permitting to reduce the menace of environmental damage;

(2) working out and implementation of new techniques and technologies permitting to reduce the use of raw materials and their recycling;

(3) working out and implementation of new techniques and technologies permitting to reduce pollutant's emission to the environment - equipment for emitted gases purification, sewage treatment, wastes conditioning, etc.;

(4) working out and implementation of new techniques and technologies enabling recultivation of devastated areas.

Regarding the above objectives of engineering in environmental protection, it is moreover necessary to point out that they may be realized at different scales. It is obvious that different methods of proceeding will be adopted in solving the problems at a scale of, for example, one industrial plant, or at the scale of vast regions.

In view of the diversity of tasks imposed on engineering in environmental protection and the diversity of scale at which the tasks may be realized, the question of the engineers' training organization and of the specialization lines required remains controversial and subject to discussion. It is also necessary to emphasize the growing disproportion between the scope of capacities expected from engineering specialists and the existing possibilities of training engineers to satisfy all requirements of the proposed scope of abilities and knowledge. One may, therefore, assume as non-controversial the following:

Thesis 2: The objectives of engineering and the tasks of engineers in environmental protection cannot be achieved by engineers of the same vocational specialization. It is therefore necessary to train engineers qualified in different specializations.

Regarding Thesis 1, it is, however, to be added that the aiming to introduce ever more engineering specializations has lately been meeting with justified criticism. It is thus necessary to proceed with considerable prudence, in keeping within reasonable needs. One may, on this ground, formulate the following:

Thesis 3: The number of engineering specializations should be limited to the necessary minimum.

Giving attention to the above two apparently contradictory theses, one should consider which of the objectives of engineering in environmental protection are the most essential, and whether all of these objectives might not be achieved by engineers of one vocational specialization. It is also necessary to answer the question of whether it is possible to suggest such a type of engineer who would be equally useful in the developing and in the highly industrialized countries. It seems that satisfying such a condition may be possible

if, as starting point, one uses the notion of "system".

Subsequent to the above statements, it is possible to formulate the following:

Thesis 4: The whole of engineering specializations in environmental protection may be classified in two groups: that of environmental management engineers, and that of environmental protection technology engineers.

Engineers of the former group will be directly concerned with environmental protection systems, or in other words, with problems of planning, administration and management at the scale of large regions; engineers of the latter group will be concerned with solving of determined engineering problems relative to the working out of installations and technological methods used to reduce environmental menaces.

Assuming that such a classification is adopted in discussion, let us now consider whether further subdivision of the two groups into still narrower specializations seems necessary.

3.4 The profile of the environmental management engineer

Based on the earlier proposed assumptions, one may suggest the following definition: environmental management engineering is a science of analytical methods and technical applications leading to optimized management, at the scale of large regions, of the various environmental elements in view to ensure social and living conditions proper to man's health and his well-being, and to enable rational utilization of natural resources.

For full clarity of the reasoning to be used as regards training, the characteristics of an environmental engineer will be illustrated by listing the scope of his abilities and knowledge in direct relation to his professional activities. Thus, the environmental management engineer should have the following abilities:

(1) Application of systems analysis principles in problems of environmental protection and management.

(2) Expression of problems needing solution in the form of algorithms and computer programmes, as well as familiarity with computer utilization in routine professional work.

(3) Planning and organization of survey networks for environmental (air, water, soil) pollution measurement.

(4) Planning and organization of pollutants emission measurement.

(5) Operation of up-to-date instrumentation for field and laboratory measurements and for various investigations.

(6) Planning of systems for data collection and processing.

(7) Design of mathematical models of pollutant circulation and transformation within the environment.

(8) Preparation of long-term forecasts on the requirements for energy, raw materials, etc., and of forecasts on the level of menace to the environment and on environmental changes.

(9) Determination of principles for raw materials management, including water and air management.

(10) Determination of principles for regional and urban planning, including proper planning of communication systems from the point of view of environmental protection.

(11) Evaluation of various industrial scale processes from the point of view of their effects on the environment, and recommendations on the necessary improvements in these processes.

(12) Evaluation of the operational efficiency of equipment used for gases purification, sewage conditioning, waste processing, etc., and recommendations on the necessary improvements.

Alongside with the above abilities, the environmental management engineer must have some knowledge in the fields of:

(1) theory of management;

(2) economics;

(3) public administration;

(4) legal regulations and standards in the area of environmental protection;

(5) regional and urban planning;

(6) epidemiology;

(7) ecology.

It seems entirely feasible to achieve the training of an engineer conforming to the above characteristics within a five-six year period of post-secondary education. It is, moreover, possible to state that the above type of engineer may satisfy most of the earlier defined characteristics of environmental engineers.

The environmental management engineer should find employment in central and local government bodies involved in management, planning and control; in the design and research divisions of important industrial corporations; in the scientific research units concerned with environmental protection. It is obvious that the demand for such types of engineers is high in both the developing and the industrialized countries. With reference to the above, it is suggested to adopt the following:

Thesis 5: The training of environmental management engineers should be considered as the basic type of specialized training of engineers in environmental protection. The need for engineers of such types is equally strong in developing and in highly industrialized countries.

Let us consider now whether, in the frame of the environmental management engineers' training, it is useful to adopt still narrower specialization lines, such as water resources management engineer, air protection management engineer, etc.

From the earlier assumed principles of a systems analysis approach to problems of environmental protection it follows that all the environmental elements should be considered as one composite unity or system. For this reason, the introduction of still narrower specialization seems unnecessary. Nevertheless, through differentiation of study programmes and provision of optional subjects, it is possible to provide for the training of graduates in selected environmental areas. The matter will be given further consideration in discussion of suggested training programmes.

3.5 The profile of the environmental protection technology engineer

In accordance with the earlier suggested division, environmental protection technology engineers represent the group of engineers designing and supervising the execution and operation of specific engineering works, installations, machinery, and equipment directly related with environmental protection. Because of the diversity of objectives imposed on engineering and of tasks facing the engineer in this area, there is, in fact, no engineering specialization that would not be useful in relation to environmental protection. For this reason, the elaboration of training programmes in specializations related exclusively to environmental protection, in which training over a five-six year cycle of education is difficult.

The first approximation will be in a trial to classify the objectives of engineering in environmental protection into related groups, with the reservation being made that any such classification will always tend to be controversial. It is, nevertheless, proposed to identify the following three groups of items:

(1) New technologies: improvement of manufacturing techniques and technologies. New materials and raw materials. Recylcing.

(2) Industrial hygiene: heating. Ventilating and conditioning. Air pollution control. Protection of radiation. Noise evaluation and control.

(3) Communal hygiene: water for domestic use. Water for industrial use. Waste water consideration. Industrial waste treatment processes. Solid waste. Collection systems. Sanitary landfill disposal. Incineration. Composting. Vector control. Sanitary consideration in food handling.

Regarding the first group of problems, training in one complete study cycle is practically impossible. Problems of engineering implying improvement of technological proceedings, of raw materials use, etc., must be dealt with by engineers directly engaging in the design of technological processes, of machinery and equipment, by mechanical, electrical, metallurgical, chemical, and other such engineers. Even appliances specifically related to the area of environmental protection, such as those serving for dust separation or gas purification, must be worked out by mechanical, electrical or chemical engineers. Similarly, all problems related to agriculture as regards use of plant protection agents likely to have a detrimental effect on the environment, have to be dealt with by agricultural engineers. Engineers of all specialization must, however, be fully conscious of the menace to the environment resulting from engineering enterprises. Moreover, any engineering design should be subject to analysis from the point of view of adopting possible improvements permitting to reduce environmental menaces. On these grounds, one may suggest the following:

Recommendation: In all disciplines and specializations of engineering education, it is recommended that the subject "Environmental protection" be introduced, closely relating the problems of environmental protection to the specific scope of problems in the engineering specialization.

Irrespective of this, it is possible to introduce into the programmes of the last year of training in some specializations some optional courses directly relative to environmental protection.

As regards the two latter groups of problems, i.e. industrial hygiene and communal hygiene, training is at present included within the scope of training in the specializations of sanitary engineering and of civil engineering. The term used for the specialization is less important, but the essential is that, based on the above division, there is a very logical programme of training. On this ground, it is suggested to adopt the following:

Thesis 6: It is proposed to assume two basic specialization lines of environmental protection technology engineers: industrial hygiene and communal hygiene.

Engineers trained in the above specialization should find employment in central and local environmental health departments, in design units and engineering units, in sanitary equipment plants, in supervision units of industrial plants, etc. It seems likely that demand for engineers of such types is considerable in all countries of the world.

4. PROPOSALS ON THE ORGANIZATION AND PROGRAMME OF TRAINING

4.1 Forms and duration of training

The very extensive scope of knowledge and abilities demanded of environmental engineers justify the proposal that university level education in its whole cycle should constitute the basic form of training in environmental engineering. Irrespective of whether, depending on the organization pattern of particular university level schools, the training be one- or two-step, it is further assumed that the total period of training be five-six years. Prior to formulating proposals for training programmes, it is assumed that each academic year includes an average of 30 weeks, and that the number of training hours amounts to 25-30 hours per week. The total of training hours is therefore assumed as 4,000 to 5,000 hours.

4.2 Classification into subject groups

Parallel to the discussion under §2, the assumption is made that one may classify science into: human and social sciences, fundamental sciences engineering sciences and specialization disciplines. In this regard, one may adopt the following:

Thesis 7: Tuition in the human and social sciences, as also in the fundamental sciences, may be common for all environmental engineers, for both environmental management engineers and environmental protection technology engineers.

As emphasized in an earlier recommendation, the human and social sciences are of dominant

importance in the education of environmental engineers. On these grounds, it is suggested to foresee at least 20% of total training time, for that subject group, that is 800-1,000 hours.

The importance of the fundamental sciences of mathematics, physics, chemistry and biology in the education of engineers, and particularly of environmental engineers, is obvious. One may only add that knowledge of them affords increased possibilities of flexible self-adaptation of graduates to the concrete tasks of engineering practice. It seems reasonable to consider 20-25% (800-1,200 hours) of total training time as the absolute minimum for these subjects.

On these grounds, the time left for tuition in engineering sciences and specialized disciplines is equivalent to 55-60% of total training time, i.e. 2,500-3,000 hours.

4.3 Human and social sciences

The choice of the scope of training in the human and social sciences will, of course, depend on tradition, differ in different countries and in different university level technical schools. No strict standards may therefore be established. It seems, however, that priority should be accorded to political economy, psychology and sociology.

It would be advisable that the teaching programmes in human and social sciences be prepared with the help of experts in these fields, as recommended by the Department of Social Sciences of Unesco, or of the Department itself.

4.4 Fundamental sciences

Definition of the scope of teaching as regards the fundamental sciences requires an estimation of the knowledge level of students admitted to the first year of university level technical education. Since the initial level may differ in various cases, it may be necessary to supplement knowledge in mathematics, physics, chemistry and biology, up to the level necessary to undertake normal engineering education, by means of a preliminary year of preparatory tuition not included in the proposed full cycle of training. On this basis, it is possible to propose a repartition of time for the teaching of fundamental sciences, as shown in Table 8.

Table 8 - Fundamental sciences

Course No.	Subject	Hours		
		Total	Lectures	Exercises and laboratory
S. F. 1	Mathematics	600-700	400-500	100-200
S. F. 2	Physics	100-150	80-100	70-80
S. F. 3	Chemistry	100-150	80-100	70-80
S. F. 4	Biology	100-150	80-100	70-80
	Total	900-1,150	640-800	310-440

Proposed syllabi in fundamental sciences are given in Annex III.

4.5 Common subjects of teaching in all specializations of environmental engineering

Independent of the earlier mentioned groups of subjects, one may identify some more common subjects of importance to all specializations of environmental engineering. These subjects and proposed teaching times are presented in Table 9.

Table 9 - Common subjects of teaching

Course No.	Subject	Hours		
		Total	Lectures	Exercises and laboratory
C. 1	Mechanics of fluids	120-150	60-90	60-90
C. 2	Environmental chemistry	120-150	60-90	60-90
C. 3	Environmental biology	120-150	60-90	60-90
C. 4	Principles of electrical engineering and electronics	120-150	60-90	30-60
C. 5	Sources of environmental hazards	120-150	100-120	30-60
C. 6	Man and his environment	90-120	100-120	30-40
C. 7	Environmental law and standards	60-90	60-90	

Proposed curricula for these common subjects are given in Annex III.

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4.6 Programme of training in the specialization of environmental management engineering

Assuming the vocational characteristic of environmental management engineers as under 3.4, and assuming adoption of the proposals concerning the groups of human and social, and of fundamental sciences, as well as of the group of subjects common to all environmental engineers, it is possible to propose a programme of training as presented in Table 10 (see Annex II). The numbers of hours for training in respective subjects are proposed in Table 10 as minimum and maximum hours, the former relating to a five-year cycle of training, the latter to a six-year cycle of training. It seems that for this specialization it would be proper to assume a six-year cycle of university level training.

The order of teaching of particular subjects need not, of course, correspond to their order in Table 10. Wherever possible, several subjects are coupled into groups of problems which may be taught as one subject, or as separate subjects, as listed in the table. This applies particularly to the subject groups of hydrology, water management, and water and waste water treatment installations.

One more remark of essential importance is necessary here: the scopes of all subjects concerning design and technology of, for example, equipment for air purification or water and waste water treatment, are supposed to acquaint the student with up-to-date trends in the given field and with the technological and economical effect of particular procedures. In principle, the training in such subjects within the proposed number of hours cannot hope to give full ability to design such equipment immediately the engineer graduates.

The basic assumption of the proposed programme of training is that all students accomplish obligatorily the full programme. Narrower specialization, on the other part, is possible in the frame of specialized seminars for which 200-250 hours are foreseen. The types of proposed specializations correspond to the training subjects or groups of subjects marked with asterisks in Table 10.

To avoid misunderstanding as regards the scope of training in particular subjects, brief descriptions are given in Annex III.

4.7 Groups of common subjects for the specialization of environmental protection technology engineers

In the programme of training foreseen regarding this specialization, one may propose some subjects as common for both industrial hygiene engineers and communal hygiene engineers. The subjects are listed in Table 11.

Table 11 - Common subjects for the specialization of environmental protection technology

Course No.	Subject	Hours: Total	Lectures	Exercises and laboratory
T.C. 1	Drawing and design	120	30	90
T.C. 2	Engineering mechanics	90	60	30
T.C. 3	Building technology	90	60	30
T.C. 4	Automatic regulation (control engineering)	90	60	30
T.C. 5	Sanitary installations	90	60	30
T.C. 6	Management and organization	90	60	30
T.C. 7	Housing and the residential environment	90	60	30

Proposed syllabi are given in Annex III.

4.8 Training programme in the specialization of industrial hygiene engineering

Taking into consideration all the subjects taught in common, one may propose the programme of training in the above specialization as shown in Table 12, Annex II. Narrower specialization may be achieved through seminars in the areas of subjects marked with asterisks in Table 12.

It seems that with regard to specialization in industrial hygiene engineering, the achievement of a full programme is possible within a five-year cycle of training. For this reason, the proposed total number of hours is 4,000. Teaching profiles for particular subjects are suggested in an abbreviated form in Annex III.

4.9 Training programme in the specialization of communal hygiene engineering

Taking into account the earlier listed subjects taught in common, one may propose the training in this specialization as shown in Table 13, Annex II.

It is assumed that completion of the programme is possible within a five-year cycle of training, giving a total of 4,000 training hours. Narrower specialization may be achieved through seminars in the areas of subjects marked with asterisks in Table 13. Teaching profiles for particular subjects are given in abbreviated form in Annex III.

4.10 Teaching personnel; equipment

Accomplishment of the proposed programmes of training is possible only in schools disposing of a staff of highly qualified specialists in the various areas, as well as of adequate laboratory equipment. Each of the proposed groups of subjects, and in some cases even each particular subject, should be organized as a Chair, Department or Institute, depending on the system used in the given school.

If one assumes that each Chair or Department corresponds to at least one professor with a team of over 10 collaborators, this means that training in any of the discussed specializations necessitates a personnel including at least 10 professors and about 100 additional scientific personnel.

Since the majority of subjects must use laboratory classes, the equipment of laboratories with up-to-date measuring instrumentation is an essential condition for carrying out the training. In all cases, students should have full opportunity to make use of computers. It is also obvious that libraries containing up-to-date books and periodicals, and a properly organized system of bibliographic references, are essential as part of the school.

In above assumptions, university level technical education is taken as a basis for the training of environmental engineers. Positive results may, however, be achieved through co-operation between such university level schools and separate specialized research institutes. Such co-operation may enable more rational utilization of scarce instrumentation and equipment.

4.11 New methods and techniques of training

Since the importance of new methods and techniques of training has been frequently discussed in the frame of Unesco and elsewhere, there is no need to further elaborate. Let us therefore only state the essential aim of tuition is, besides giving the student the range of abilities and knowledge necessary for his future professional activities, the development of the capacity of independent thought. This aim may be achieved only by consistently motivating the student to individual effort and by developing in him attitudes that will facilitate the work of the teachers. The use of seminars and of team research and laboratory work directed at the solution of specific problems is essential in this regard.

Positive results in training are therefore possible only in cases where the respective Chairs or Departments carry out their own investigations relative to the needs of the given country or region, and if the students take an active part in such research activities.

4.12 Training facilities

Independent of laboratory equipment, essential aids in training are manuals, sample calculations, instructional films, algorithms and computer programmes. Such facilities will be of particular importance to units undertaking or developing training in environmental protection. Essential assistance is here to be expected of international organizations, and particularly of Unesco and WHO.

4.13 Post-graduation courses

Even a well organized teaching programme, based on the current state of science and employing the most up-to-date methods of teaching, still would not be able to cope with all the needs of the present-day world. There is always a gap between the education given by schools and the actual situations in science, technology and social and economic structures, which are in continual evolution. The need for permanent education is thus becoming more and more urgent. It is not necessary to stress the contribution of Unesco in what concerns the creation of this concept and its diffusion in the world. Post-graduation courses obviously compose a part of the permanent education. One may distinguish the following kinds of post-graduation training:

(1) Post-graduation specialization courses for specializations related to environmental engineering. Such courses should, in principle, take 1-1.5 years, and should enable the completion, in abridged form, of one of the three programmes proposed for training in a full cycle.

(2) Post-graduation advanced qualification courses for environmental engineers. These should be short duration (several weeks) courses of training devoted to chosen problems of environmental protection.

(3) Post-graduation courses of complementary training for engineers of other specializations, such as for mechanical, chemical, electrical, and civil engineers. These courses should be of short duration (several weeks) and devoted to the latest achievements of engineering and technology in environmental protection relative to the occupational activities of the respective group of engineers.

(4) Courses for teaching personnel, meant for the academic staff of university level schools. These should be short duration (several weeks) courses devoted to chosen problems relating to the latest world-wide developments in the area of environmental protection.

Training courses of the above types may be organized on a national scale, but a particularly important rôle is here to be played by international organizations. With this background, it is possible to formulate the following:

Recommendation: The organization of different types of training courses in environmental protection should continue to be sponsored by international organizations, including Unesco.

5. FINAL REMARKS

The rapidly growing threat to the environment constantly increases the demand for specialists, in the scope of environmental protection and particularly for engineers. Training of environmental

engineers will therefore be increasingly developed by the institutions already engaging in such training, and will be undertaken in countries and institutions where to date such training has not been provided. The assistance of Unesco is essential in this field, especially concerning recommendations on the organization of training programmes.

The proposed training programmes suggested in this paper are, of course, given as a basis for analysis and discussion which will hopefully lead to the formulation of recommendations that will be more explicit and able to be widely used.

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ANNEX I

CURRENT TEACHING PROGRAMMES

Table 2 - Illustrative programme in sanitary engineering (Sao Paulo University)

Course No.	Course title	Number of hours
	Fundamental compulsory courses	
1.	Sanitary management	62
2.	Sanitation	70
3.	Water supply and sewage systems	111
4.	Domestic and waste water treatment	102
5.	Sanitary chemistry	121
6.	Parasitology	32
7.	Applied statistics	103
8.	Applied microbiology	61
9.	Epidemiology	36
10.	Applied social sciences	54
	Optional courses	
11.	Statistics and sampling	28
12.	Demographical statistics	45
13.	Mathematical statistics	(several courses)
14.	Food technology	28
15.	Industrial hygiene	57
16.	Heating and ventilation	45
17.	Aquatic biology	55
18.	Sanitation (special problems)	58
19.	Land use management and sanitation	41
20.	Water supply and sewage systems	40
21.	Hydrology	45
22.	Sewage and pipelines	19
23.	Domestic and waste water treatment -	
	Special problems	29
	Design and planning of water treatment systems	16
24.	Advanced course in public health management	(several courses)
25.	Methodology of research in social sciences	44
26.	Sanitary education	40
27.	Audio-visual practice (laboratory)	28

Table 3 - Illustrative two-year programme (MSEE) in water quality management (University of North Carolina at Chapel Hill)

Course No.	Course title	Hours a week	
		Lecture	Seminar and laboratory
1	2	3	4
	1st year		
	Fall semester		
1.	Probability and statistics		
2.	Water chemistry	2	2
3.	System analysis in environmental planning	3	-
4.	Principles of water quality management	1	2
	Spring semester		
5.	Water and wastes treatment processes	3	2
6.	Water and waste water treatment plant design	2	2
7.	Biology in environmental sciences	2	2
8.	Sanitary engineering problem	-	2
	Summer semester		
9.	Engineering project design	6	-
10.	Sanitary engineering problem	-	3-6
11.	Special project in water quality planning	3	-
	2nd year		
	Fall semester		
12.	Water supply and waste water disposal systems	2	2
13.	Limnology and water pollution	2	2
14.	Chemical reaction engineering	3	2
15.	Natural resources law and policy	3	-
	Spring semester		
16.	Epidemiology in environmental health	3	-
17.	Industrial water quality management	2	2
18.	Topics in advanced hydrology	3	-
19.	Special topics in aquatic chemistry	2	-
20.	Reading problem or elective	3	-

Note: Each student must take at least two courses in the School of Public Health outside the Environmental Science and Engineering Department.

Table 4.- Illustrative two-year programme in air pollution control (MSEE or MSPH)

Course No.	Course title	Hours a week: Lecture	Hours a week: Seminar and laboratory
1	2	3	4
	1st year		
	Fall semester		
1.	Elements of probability and statistical inference.	3	-
2.	Air pollution measuring, monitoring and survey	1	4
3.	Mechanics of aerosols	3	-
4.	Air and its contaminants	3	-
5.	Meteorology	3	-
	Spring semester		
6.	Problems in air pollution	4	-
7.	Industrial hygiene practices	2	2
8.	Air pollution control	3	-
9.	Air pollution meteorology	3	-
10.	Epidemiology in environmental health	1	2
	2nd year		
	Fall semester (stresses planning and administration)		
11.	Environmental system analysis: deterministic models	3	-
12.	Industrial water quality management	2	2
13.	Natural resources law and policy	3	-
Two of the following:			
	Introduction to urbanism and planning	3	-
	Planning theory	3	-
	Urbanism seminar	3	-
	Planning and co-ordination	3	-
	Municipal government in the United States of America	3	-
	State politics and public policy	3	-
	Urban political systems	3	-
	Planning and government	3	-
	Government and politics in metropolitan areas	3	-
	Intergovernmental relations	3	-
	2nd year		
	Spring semester		
16.	Elements of statistical analysis	3	-
17.	Environmental systems analysis II: probabilistic models	3	-
18.	Problems in air pollution	3	-
Two of the following:			
	Transportation and technologic systems	3	-
	Urban economics	3	-
	Regional science techniques	3	-
	Metropolitan analysis and development	3	-
	Planning law	3	-
	Land use systems	3	-
	Environmental planning	3	-
	Municipal administration in the United States	3	-
	Administrative theory	3	-
	Public administration and policy-making	3	-
	Law and public policy	3	-
	Legal problems in public administration	3	-

Table 5 - Example of a one-year programme of study in environmental management (MSPH)

Course No.	Course title	Hours a week: Lecture	Hours a week: Seminar and laboratory
1	2	3	4
	Fall semester		
1.	Principles of statistical inference	3	-
2.	Systems analysis in environmental planning	3	-
3.	Public investment theory and techniques	3	-
4.	Public administration and health	3	-
5.	Principles of water quality management	1	2
	Spring semester		
6.	Planning and development of environmental hygiene programmes	2	2
7.	Natural resources law and policy	3	-
8.	Epidemiology in environmental health	1	2
9.	Public administration and policy-making	3	-
10.	Environmental planning	3	-
	Summer session		
11.	Engineering project design	6	-
12.	Man and his environment	3	-
13.	Problems	6	-

Table 6 - Illustrative five-year programme in air pollution control (Politechnika Warszawska)

Course No.	Course title		Hours total
	Human sciences		832
	Fundamental sciences		
1.	Mathematics		352
2.	Probability and statistics		144
3.	System analysis		96
4.	Computer programming		96
5.	Physics		160
6.	Theoretical mechanics		80
7.	Chemistry		128
		Total:	1,056
	Engineering sciences		
1.	Mechanics of fluids		160
2.	Thermodynamics		80
3.	Technical design		64
4.	Geodesy		64
5.	Electrotechnics and electronics		80
6.	Instrumentation and measuring		160
		Total:	608
	Specialization disciplines		
1.	Environmental chemistry		96
2.	Environmental biology		80
3.	Principles of hydrology		64
4.	Dynamics of the troposphere		128)
5.	Meteorology		160)
6.	Industrial sources of environmental pollution		124
7.	Air pollution measuring, monitoring and survey		192)
8.	Air pollution meteorology		192)
9.	Air pollution control technology		144)
10.	Elements of environmental protection		160
11.	Urban and regional planning		112
12.	Specialization seminars		192
		Total:	1,644
		Grand total:	4,140

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Table 7 - Course programme

Sanitary Engineering Centre, Rabat
International Training in Sanitary Engineering

Course No.	Course title	Hours: Lecture	Design	Laboratory
1	2	3	4	5
	1st Group			
1.	Complementary civil engineering and hydraulics	45	-	-
2.	Sanitary microbiology	45	-	38
3.	Sanitary chemistry	45	-	45
4.	Domestic water treatment	30	30	18
5.	Waste water purification	45	45	38
6.	Habitat and urbanism	30	-	-
7.	Rural sanitation	23	-	-
8.	Air pollution and industrial hygiene	23	15	-
9.	Domestic wastes disposal and treatment	10	5	-
10.	Complementary urban hydraulics	15	-	-
11.	Seminars	-	30	-
	2nd Group			
12.	General hygiene and parasitology	30	-	-
13.	Statistics and epidemiology	15	7	-
14.	Paludism and zoonoses	23	10	-
15.	Tropical hygiene	15	-	-
16.	Food salubrity hygiene	23	10	-
17.	Sanitary education	9	-	-
18.	Public health administration	10	-	-
19.	Elements of nuclear hygiene and of radioactive waste disposal	15	-	-
20.	Visiting and conferences	-	38	-
	Total:	451 (58%)	190 (24%)	139 (18%)

The following programme is based on the following scheme:

1. Two semesters per academic year.
2. Each semester of fifteen weeks.
3. Each academic year including a total of 780 hours, comprising lectures, practical work, seminars, visits and conferences.
4. Each week has 26 hours of effective activities, not including the student's individual work.
5. Theoretical courses amounting to 58% of the programme.

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ANNEX II

PROPOSED TEACHING PROGRAMMES

Table 10 - Teaching programme in environmental management

Course No.	Subject	Hours: Total	Lecture	Exercise and laboratory
H. 1	Human and social sciences	800-1,000	600-700	200-300
S. F. 1	Mathematics	600-700	400-500	200-300
S. F. 2	Physics	100-150	60-90	40-60
S. F. 3	Chemistry	100-150	60-90	40-60
S. F. 4	Biology	100-150	60-90	40-60
C. 1	Mechanics of fluids	120-150	60-90	60-90
C. 2	Environmental chemistry	120-150	60-90	60-90
C. 3	Environmental biology	120-150	60-90	60-90
C. 4	Principles of electrical engineering and electronics	120-150	60-90	30-60
C. 5	The sources of environmental hazards	120-150	100-120	30-60
C. 6	Man and his environment	90-120	100-120	30-40
C. 7	Environmental legislation and standards	60-90	60-90	-
M. 1	Thermodynamics	90-120	60-90	30-60
M. 2	Measuring methods	150-180	90-120	60-90
M. 3	Environmental information systems	120-150	60-90	60-90
H. C. 1*	Hydrology and water management	150-180	90-120	60-90
H. C. 2	Water and waste water treatment	120-150	90-120	30-60
M. 4*	Meteorology and atmospheric diffusion	150-180	9[illegible]20	60-90
M. 5	Air pollution control	150-180	90-120	30-60
H. C. 3	Solid waste treatment	90-120	60-90	30-60
M. 6	Environmental planning	90-120	60-90	30-60
M. 7	Environmental system analysis	150-180	60-90	60-120
M. 8	Engineering drawing	90-120	30-60	60-90
M. 9	Specialization seminars	200-250	60-90	140-190
	Grand total:	4,000-5,040	2,490-3,360	1,440-2,300

Table 12 - Teaching programme in industrial hygiene engineering

Course No.	Subject	Hours		
		Total	Lecture	Exercise and laboratory
H. 1	Human and social sciences	800	600	200
S. F. 1.	Mathematics	600	400	200
S. F. 2	Physics	100	60	40
S. F. 3	Chemistry	100	60	40
S. F. 4	Biology	100	60	40
C. 1	Mechanics of fluids	120	90	30
C. 2	Environmental chemistry	120	60	60
C. 3	Environmental biology	120	60	60
C. 4	Principles of electrical engineering and electronics	120	90	30
C. 5	The sources of environmental hazards	120	90	30
C. 6	Man and his environment	90	60	30
C. 7	Environmental legislation and standards	60	60	-
T. C. 1	Drawing and design	120	30	90
T. C. 2	Engineering mechanics	90	60	30
T. C. 3	Building technology	90	60	30
T. C. 4	Automatic regulation (control engineering)	90	60	30
T. C. 5	Sanitary installations	90	60	30
T. C. 6	Management and organization	90	60	30
T. C. 7	Housing and the residential environment	90	60	30
H. I. 1	Thermodynamics	150	90	60
H. I. 2	Heating, ventilation and conditioning	270	150	120
H. I. 3	Lighting	90	60	30
H. I. 4	Noise evaluation and control	90	60	30
H. I. 5	Protection from radiation	90	60	30
H. I. 6	Specialization seminars	200	60	140
	Grand total:	4,000	2,570	1,430

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Table 13 - Teaching programme in communal hygiene engineering

Course No.	Subject	Hours: Total	Hours: Lecture	Hours: Exercise and laboratory
H. 1	Human and social sciences	800	600	200
S. F. 1	Mathematics	600	400	200
S. F. 2	Physics	100	60	40
S. F. 3	Chemistry	100	60	40
S. F. 4	Biology	100	60	40
C. 1	Mechanics of fluids	120	90	30
C. 2	Environmental chemistry	120	60	60
C. 3	Environmental biology	120	60	60
C. 4	Principles of electrical engineering and electronics	120	90	30
C. 5	The sources of environmental hazards	120	90	30
C. 6	Man and his environment	90	60	30
C. 7	Environmental legislation and standards	60	60	-
T. C. 1	Drawing and design	120	30	90
T. C. 2	Engineering mechanics	90	60	30
T. C. 3	Building technology	90	60	30
T. C. 4	Automatic regulation (control engineering)	90	60	30
T. C. 5	Sanitary installations	90	60	30
T. C. 6	Management and organization	90	60	30
T. C. 7	Housing and the residential environment	90	60	30
H. C. 1	Hydrology and water management	150	90	90
H. C. 2*	Water and waste treatment processes	180	90	90
H. C. 3*	Solid waste collection treatment and management	180	90	90
H. C. 4	Vector control	90	60	30
H. C. 5	Food sanitation and hygiene	90	60	30
H. C. 6	Specialization seminars	200	60	140
	Grand total:	4,000	2,530	1,470

ANNEX III

SUMMARY OF SPECIFIC SUBJECTS TEACHING PROFILES

Remarks

All suggestions presented here are to define, in principle, merely the scope of training. The elaboration of details requires consultation with specialists in particular fields.

In the programme of training of environmental management engineers and of environmental protection technology engineers, mention is made of subjects having the same title and covering the same scope of training. In the case of environmental management engineers, knowledge of the problem should, in principle, cover the technological and economical effect of particular systems or installations. In the other case, it refers to the ability of designing such systems or installations.

1. Fundamental sciences (S. F.)

S. F. 1 - Mathematics

A. Fundamental mathematics. Sets and numbers. Metric and vector spaces. Differential calculus of single variable function. Function analysis. Simple integrals. Geometrical and physical application of definite integrals. Simple differential equations. Matrices, linear equation systems. Analytical geometry of solids. Multiple variable functions. Binary and ternary integrals. Curvilinear and superficial integrals. Elements of vector analysis. Function sequences and series. Complex variable functions. Elements of topology.

B. Statistical methods and calculus of probability. Random events. Conditional random events. Probability of random events. Entropy of event sets. Measures of information. Elements of Marcov processes. Random variables. Distribution of random variable functions. Random samples. Evaluation of probability by random sample. Estimation of distribution parameters. Hypothesis testing. Regression analysis. Theory of prediction.

C. Optimization methods. Mathematical programming models. Linear, non-linear and dynamic programming. Stochastic programming.

D. Computer programming and numerical methods. Computation and numerical methods in application to science and engineering. Fundamental blocks of typical computers. Fundamental notions of programming. FORTRAN and ALGOL. Numerical methods. Approximate numerical integration. Numerical differentiation. Interpolations and approximations. Matrix algebra. Methods of algebraical linear and non-linear equations. Approximative resolution of differential equations.

The notion of "engineering mathematics" is understood in different ways. The whole of the proposed scope of teaching should, therefore, be subject to detailed discussion amongst specialists.

Teaching of the whole material may be conducted in one sequence, that is, divided into separate elements. Provision should be made that mathematics be taught for at least three years. The number of hours needed to achieve the complete programme of training including exercises may be estimated as equivalent to 600-700 hours.

S. F. 2 - Physics

Rigid body dynamics. Kinds, classes and properties of physical fields. Motion in the field of forces. Damped oscillation and forced vibration. Wave equation. Elements of room acoustics. Infra and ultrasounds and their application to engineering. Equation of the kinetic theory of gases. Entropy and probability. Physical interpretation of thermodynamic equations. Phase transitions. Phenomena of mass, momentum and energy transport in gases. Diffusion, osmosis, surface tension and viscosity of fluids. Quantum theories. Electrostatic field and its properties. Electrical conductivity in fluids and gases. Magnetic field. Electromagnetic waves. Thermal radiation. Radiation quanta. Radiation quantum energy, mass and momentum. Quantum model atom. Nuclear energy. Reactions of atomic nucleus fission and analysis.

S. F. 3 - General chemistry

The fundamental terms, laws and chemical reactions. The inorganic compounds of the chemical elements from the "s, p, d, f," blocks. The structure and properties of these chemical elements. The inorganic compounds important in consideration of the environment and human health protection. The fundamental methods of the qualitative and quantitative analytical chemistry. The classification of properties and organic compounds reactions. The organic compounds important in considering the protection of the environment and the human health. The fundamental qualitative analysis of the organic compounds.

S. F. 4 - General biology

Essential knowledge of taxonomy, morphology, physiology, parasitology, ecology of plants and animal ecology. Elementary knowledge of the human ecology and ecological systems action.

2. Common subjects of teaching in all specializations of environmental engineering (C)

C. 1 - Mechanics of fluids

Hydrostatics. Fluids in motion. Types of flow. Applications of Bernouilli equation. Laminar

and turbulent flow. Viscosity of a fluid. Flow in pipes. Orifice. Ajutages. Obstacles. Centrifugal pump. Methods of flow measurement.

C. 2 - Environmental chemistry

Chosen chemical processes in natural and polluted environment. Physical and chemical examinations of water, waste water, sediments and soil in sanitary learning. Methods of instrumental qualitative and quantitative analysis and their application in continuous or automatized checking of air, water and soil pollution: optical methods, mass spectrometry, electrochemical methods, isotopic methods and techniques, chromatographic methods. Application of chemical methods and techniques in the environment protection and purification processes.

C. 3 - Environmental biology

Sources and ways of spreading infectious diseases, and environment quality criteria from the sanitary point of view. Autopurification processes of water, air and soil, and their utilization in environmental protection. Utilization of microbiological processes in waste water, sediments and solid waste neutralization. Biological methods to estimate the impendence and the effectiveness of means in processes of environmental protection.

C. 4 - Principles of electrical and electronic engineering

Units. Electric field. Magnetic field. Electromagnetism. Electrolysis. Induction. Transformers. Electronics. Rotating machines. Methods of measurement.

C. 5 - Sources of environmental hazards

Industry, transport, housing, agriculture as sources of residues and wastes (solids, liquids, gases) and physical factors (heat, vibrations, radiations, etc.). Relative emission values.

C. 6 - Man and his environment

Environmental hazards - biological, chemical, physical, psychological, sociological. The effects on human beings, on animals and vegetation, on materials. Elements of human ecology.

C. 7 - Environmental legislation and standards

Quality criteria and standards - air, water, food. Standards of vibrations, noise, radiation. Environmental legislation.

3. Common subjects for the specialization of environmental protection technology engineers (T.C.)

T. C. 1 - Drawing and design

Knowledge of technical drawing sufficient to enable the execution of installations' designs.

T. C. 2 - Engineering mechanics

Analysis of stresses and deformations. Beams. Board. Dynamic and thermal effects. Fatigue. Soil mechanics. Statistical methods.

T. C. 3 - Building technology

Building materials. Prefabricated elements. Functionality principles of building - housing, administrative, industrial, etc. Stability, durability and maintenance. Execution of traditional building. Systems of industrial building. Thermal and sound insulation.

T. C. 4 - Automatic regulation (control engineering)

The controlled system and stability criteria. Process characteristics. Controller characteristics. Control elements. Pneumatic control. Electrical control. Electronic control. Miscellaneous topics. System design.

T. C. 5 - Sanitary installations

Calculation and technology of pipes, channels, reservoirs. Building materials. Water distribution inside buildings. Cocks. Waste water disposal. Sewage. Ventilation. Drain traps. Lavatory appliances. Kitchen, bathroom. Other installations.

T. C. 6 - Management and organization

Firms operating on both large and small scale. Source of finance. Finance control. Price policy. Costing and estimating of the industry. Production control. Research and development. Human relations in industry. Management principles.

T. C. 7 - Housing and the residential environment

Health aspects of housing. Planning, zoning and development control. Building regulations. Housing design standards. Appraisal of housing and of its environment. International housing conditions and programmes.

4. Programme of training in the specialization of environmental management engineering (M)

M. 1 - Thermodynamics

Thermodynamic analysis in applications to air and water protection, including: thermodynamics of gas mixtures; combustion; energy, heat and mass transfer systems.

M. 2 - Measuring methods

Instrumentation and techniques for measuring of air, water and soil pollution. Measurement of meteorological and hydrological data. Calibration methods.

M. 3 - Environmental information systems

Source inventory methods. Collection of data. Air and water quality monitoring. Monitoring systems. Selection of instrumentation and methods. Number and location of sampling sites. Sampling frequency and duration. Interpretation of data. Computation and data processing.

M. 4 - Meteorology and dispersion of pollutants in the atmosphere

Theory of diffusion of air pollutants. Models: theoretical, empirical and analogue. Application to practical problems and computation. Single and multiple sources. Modelling of diffusion. Stack design from the meteorological point of view. Pollutants transformation.

M. 5 - Air pollution control

Prevention at the source - energy saving, exchange of technology. Dust removal techniques. Purification techniques - nitrogen oxides, sulphur dioxides and other gas pollutants. Technological and economical effect of respective systems or installations.

M. 6 - Environmental planning

Problems and issues in urban and regional planning. Resources and industrial growth potentials in new areas. Population forecast and study of causes and effects of population migration to megalopolitan areas. New cities and their needs - economic, social, cultural, industrial, commercial, transportation, etc. Land use planning. Recreation needs and their rôle in planning. Pollution problem in urban and regional planning.

M. 7 - System analysis

Concepts of system analysis. Modelling of environmental and urban systems. Model construction and analysis in an uncertain environment.

M. 8 - Drawing and technical design

Knowledge of technical design sufficient to enable reading of maps and of installations design drawings. Ability to draw installations diagrams.

5. Programme of training in the specialization of industrial hygiene engineering (H. I.)

H. I. 1 - Thermodynamics

Thermodynamic analysis of engineering systems, including thermodynamics of gas mixtures, physical chemistry of combustion, and thermodynamic book-keeping for mass, energy and entropy. Applications to combustion, power cycles, refrigerator cycles, etc. Heat transmission - conduction, radiation, convection. Calculation and design of heat and mass transfer systems. Measurement.

H. I. 2 - Heating, ventilation and conditioning

A. Heating. Calculating of the total heat loss for the building. Heat generation systems. Heating systems - hot water, steam, air. Individual apartment and urban heating. Thermal boiler stations. Control and maintenance. Calculation and design of installations. Measuring methods.

B. Ventilating. Natural and artificial ventilating. Exhaust. Fans. Ventilating systems - residences, public buildings and facilities, industrial, etc. Automatic control and maintenance. Calculations and design of ventilating systems. Measurement and instruments.

C. Air control. Theory and practice of dust precipitators and air filters. Automatic control and maintenance. Calculations and design of air control systems. Measurement and instruments.

D. Air-conditioning. Process and product of air-conditioning. Engineered refrigeration systems. Automatic control and maintenance. Calculating and design of air-conditioning systems. Measurement.

H. I. 3 - Lighting

Language of light. Light sources. Lighting units. Lighting requirements and design - residences, office, hospital, industry. Light measurement.

H. I. 4 - Noise evaluation and control

The physics of sound. Noise measurement. Noise control - by insulation, by vibration damping. Barriers and partial enclosures for noise control. Noise control systems - residences, public buildings, industrial, etc.

H. I. 5 - Protection from radiation

Use and sources of ionizing radiation. Effects of radiation. Radiation measurements. Protection from radiation.

6. Programme of training in the specialization of communal hygiene engineering (H. C.)

H. C. 1 - Hydrology and water management

Groundwater occurrence and exploration. Estimation of water needs and water resources study. Status and trends for the future. Water resources planning, conservation, development and management. Application of systems analysis.

H. C. 2 - Water and waste treatment processes

Drinking water treatment processes - sedimentation, filtration, disinfection, demineralization, chemical improvement. Water for industrial use - characteristics, treatment. Water supply, waste water collection systems. Treatment processes - preliminary, primary, secondary, tertiary disinfection. Sludge treatment. Industrial waste treatment processes. Combined industrial and domestic waste treatment. Economics of waste treatment systems.

H. C. 3 - Solid waste collection, treatment and management

Collection systems. Sanitary landfill disposal - process, equipment and operation, biological activity, site selection and land use. Composting. Incineration. Hydropulping. Industrial solid waste treatment processes. Economics of solid waste systems.

H. C. 4 - Vector control

Mosquitoes, flies, cockroaches, spiders, ticks, bedbugs, rodents - technical means of prevention.

H. C. 5 - Food sanitation and hygiene

Hygienic transport, storage and distribution of food and beverages. Control of contamination by chemical and biological agents.

ENGINEERING EDUCATION AND THE ENVIRONMENT

by James M. Ham(*)

INTRODUCTION

This paper gives the author's views of how the shape of engineering and technical education as a whole should respond to concern for the environment. It does not address the problems of the education of specialists in environmental studies and management (such as the traditional sanitary engineer or the environmental health engineer (1). The approach is from technology to the environment rather than the converse.

Although intense public concern about the impact of human activity on the environment has arisen only during the past two decades, the processes which are at the roots are historic, and it is important to set an historical perspective for this paper.(**) This is especially important to understanding that diversity of views which will be taken by countries in different states of technological development (2-6). One's attitude to the environment depends in particular on one's perception of "frontiers". Frontiers are regions available for activity that have unclearly perceived limits. For most of us the very air, the water of lakes and rivers and the soil under our feet have functioned and continue to function as frontiers. To the economist air and water have been "free goods". But apart from conceptual frontiers, major local frontiers exist for many countries, for example, the Amazon Basin for Brazil, the Arctic for Canada, the virgin lands of Siberia for the USSR.

Now, however, for the first time the space exploration programmes of the USSR and the U.S.A., together with modern communications systems, have revealed the earth to the public consciousness as a closed finite system, a global spaceship.

Technology and man

Whereas science has the single undergirding purpose of discovering what is general in what is particular, engineering has the purpose of particularizing out of what is generally possible - to build cities, roads, ships, power stations, chemical plants - to mine, to forest, to fish, to farm. The purposes expressed in the technology, which is the progeny of engineers, architects, artisans and artists are diverse - a complex of personal, corporate, social, national and international perceived needs and aspirations. Technological artefacts and systems thereof created by the purposeful activity of man through the shaping of materials, the control of forces and the structuring of information are all interventions in the natural order in the sense that they are planned, designed, constructed, operated, administered where none were there before. The natural ecosystem including man as a species develops by the interaction of teleonomically generated elements (plants, animals, insects, birds). Human activity as expressed in technology, industry and institutions is an expression of the teleology of man. The sciences function to establish some of the limits of possibility for technology but they do not determine specific outcomes. Specific outcomes are the result of human intent. Polanyi (7) has explained that the essential difference between science and engineering is in attitude to imposed boundaries. Thus when a chemist contains an aequeous solution within the boundaries of a test tube his interest is in the solution not in the test tube. On the other hand when an engineer devises an operational steam engine out of shaped elements such as pistons, valves, levers and gears, his interest is in the functional performance achieved by imposing boundary conditions and constraints.

Technological intervention in the environment must be seen in its three complementary aspects:

(i) of protecting man from the threats of the environment - pestilence, starvation, storm, cold

(ii) of contributing to the development of man himself

(iii) of protecting the environment from ill conceived intervention.

The first two aspects are associated with the historic processes of technological development. The last relates to the impact of industrializing man on the biosphere. In Roman civilization, for example, the deforestation of the Mediterranean basin changed the macroclimate of the region while the use of lead in food utensils had dysgenic effects on the Roman leadership (8). Neither effect was recognized at the time. In a complementary

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(**) In the historical classic on mining and metallurgy, De Re Metallica published in Basel in 1556 by Agricola (George Bauer) the author wrote: ...It remains for me to speak of the ailments and accidents of miners, and the methods by which they can guard against these, for we should always devote more care to maintaining our health, that we may freely perform our bodily functions, than to making profits... Dover Publications Inc., N. Y., 1950, Book VI, p. 214.

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way, the introduction of the ox-drawn iron plough in the Middle Ages did much to alter European man's attitude to the earth from that which is the origin of necessary sustenance to that which is a resource to be exploited (9). Yet at all times technological intervention has been part of the impetus to survive in a far from benign total environment which is increasingly dominated by the artefacts of man, and in particular his cities.

Since human intent has diverse expression in the cultural and political history of many nations, it is reasonable to expect there to be diversity in the processes of reconciling technological creativity with the inherent consequences of intervention in the natural ecosystem. One may conclude from these brief remarks that it is encumbent upon the engineering schools of each of our countries to teach with clarity an appreciation of how the processes of technological change are perceived and motivated as regards social, economic and environmental development. Our engineering education has been too insensitive to the historical roots of the relationships between technology and man (10, 11). The new concern for the environment can be a stimulus to strengthen studies of the social sciences and humanities that are integrally and not peripherally related to the rôles of engineers and of other technical cadres. The problem we face is not simply of scientific knowledge and management expertise but of attitudes and intent.

Which environment?

From the point of view of engineering there are many foci of environmental concern. The following are examples:

The immediate envelope of air and moisture surrounding a person in a building (12).

The city as a place to live (4, 13).

The need of a city for water and waste disposal (14).

The environment of vibration, dust and wind associated with a machine or building (15).

The interaction of an industry such as steel with its environment of air, water, soil and people (16, 17).

From such typical examples chosen with an engineering perspective one may reach out to regional problems of human well-being associated with solid wastes (18) and indeed to a global framework (19-22). In recent years it has been mainly other than engineers who have had a broad perspective and this is a point that requires understanding and redress in the education of all engineers and similar professionals.

Although it is a distinctive attribute of a good professional engineer to understand the context of his own work, for example, for a designer of steam turbines to understand the relation of the waste products of fuel combustion and of waste thermodynamic heat to the processes of energy conversion in a power station, such technological awareness is not universal and a concomitant sensitivity to questions of environmental impact is less so. Historically, specialization of rôle and of supporting labour are largely to blame. While division of labour has, as part of the economics of scale, contributed greatly to the efficiency of technological methods for producing and replicating machines and their products, it has also contributed to social as well as environmental disturbance. In this regard it is well not to have utopian expectations of engineers as environmentalists per se. However, there is a distinctive basis for an important contribution.

The limitations and potentialities of engineering

In designing to realize a given operational principle in a machine or process, the engineer particularizes out of what is generally possible and in the effort to achieve an effective and economical design must concentrate on the purpose at hand. It is intrinsic that the development of an engineering design cannot encompass all of the consequences of the creation of the technology either in terms of its use for intended purposes or in terms of its unintended uses. This shortcoming may be termed the frailty of design.

In this connexion it is useful to note that modern technology unlike ancient technology is self indicting. Whereas lead poisoning (8) was dysgenic in late Roman civilization because the knowledge and instruments were not available to trace the effects, modern technology provides the precise instrumentation necessary to follow trace-elements such as mercury through the pathways of our ecosystems. It is the proper rôle of science to reveal the secondary effects of technology by seeking to understand "nature" as modified by the technological interventions of man. The rôle of science is thus extended from establishing the limits of possibilities for engineering design to developing awareness of the consequences that result from action. Since modern technology provides to science the precise instruments required to trace its effects, it has become self-indicting.

All technology will have effects unexpected by its designers and users both in the short and the long term. Lead utensils poisoned Romans. Waterwheels, windmills, ploughs, steam engines, dynamos, automobiles, refineries not only have met immediate purposes but have contributed, in time through numbers, to transformation of nations - industrially, socially and environmentally.

All engineering education should, therefore, contain some study of the historical evolution of technology and particularly of the effects of populations of machines. While the purposes expressed in the design of a machine or process may appear to an engineer to be his own, when machines and products thereof are replicated (manufactured and distributed) the purposes being served are those of commercial corporations, the state and society.

Environmental studies for engineers should, therefore, be directed not simply at developing

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sensitivity to the secondary environmental consequences of technological intervention, but particularly at the historical experience of creating technology as a purposeful part of the venture of man himself on the face of the earth. Through such a view engineering education can bring to the environmental issue a unique perspective that it has yet failed to articulate (11). The problems we face are as much those of understanding the process of development and the embedded relations of machines to men as they are of understanding the consequences of technological intervention in the ecosystem. In this perspective there is a need to involve all students and staff in our engineering schools. Engineering schools must be concerned to have a balanced appreciation about both development and the environment. Within such a perspective there should be no want of student motivation in any of our countries.

Engineering education and the environment: Strategy of development

There are basic features in the structure of engineering education as a whole which deter the working out of a new sensitivity to the environment and these are the same features which have deterred a sensitivity to the historical rôle of technology in national development. Good engineering education with its distinctive profile of the sciences (mathematics, physics, chemistry, biology), the engineering sciences (thermodynamics, mechanics, rate processes, information systems, etc.), design applications and an infusion of social sciences (especially economics) and the humanities has been and will remain a demanding exercise in which it is essential to retain a basic profile with a hard core. The mere injection into the status quo of optional or required subjects specifically oriented towards environmental problems is not satisfactory. The basic strategic problem is to develop an environmental awareness in the whole school, an awareness which can well take the regional context of the school itself as a focus. The director of the Environmental Studies Programme at the University of Toronto, Dr. F. K. Hare, an eminent geographer, recently had this to say;

> ... I believe that the way to alter curricula is to do it from within, by civilizing the teacher... Most courses gain immensely if the teacher stands back a little and spends a few minutes speculating aloud about the significance of what he is proposing... It would be possible in this and every other university to give an outstanding degree course in the environment without changing a word in the calendar... All I ask of engineers is all I ask of myself: to inject into their subjects the maximum degree of attention to environmental options that the hard core permits. This means an extremely intensive re-education of oneself, a willingness to listen to the environmental debate with an acute, critical but receptive ear...

Whatever the merits of these remarks at the tactical level of curricular design, they represent in my view an essential strategic point. I would extend this strategic base to include a complementary awareness of the history of technology as relates to the process of development. Technology represents purposeful intervention in the complementary spheres of the ecosystem and of the society of men. It is the combination that represents the environmental problematique. To the developmental part of the problematique engineering schools themselves have a singular contribution to make.

It is in my view essential therefore that Unesco and UNEP continue to work together on these issues.

Tactics of awareness

Everyone agrees that, intellectually, environmental problems are multidisciplinary and interdisciplinary, and that, socially, they are intersectoral involving communities, industries and governments. A number of practical programmes may be undertaken to develop broad awareness within educational institutions. One that I consider important is that of conducting a study with the aim of obtaining A regional appreciation of development and the environment. The appreciation should not attempt to be prescriptive nor condemnatory but rather should seek to generate a perspective on the interaction between technological development and the environment within perceived national needs and priorities. The UNEP and Unesco might combine to direct the preparation of a number of guideline documents to facilitate the preparation of such appreciations. What is proposed here is something broader than specialized studies on water resources, sanitation, etc., but not a full-fledged development plan.

By whom such an appreciation is prepared depends on its purpose. The major purpose should be to develop in the associated university(s) or technical institution(s) an awareness of the environmental and developmental context of their educational mission. Such a study can provide a nucleus of local understanding undistorted by the weight of world literature which at present is dominantly concerned with problems of acute industrialization. Since it is the responsibility of governments and not universities to plan, the study is most likely to be done by university staff and students who call upon industry and government for assistance. Engineering staff should expect to co-operate with chemists, physicists, geographers, sociologists, economists, historians. The study is a form of local initiative which must have government support and may provide the basis for a distinctive United Nations programme.

A crucial issue in execution is co-operation at the sectoral interfaces. Much has been written about the university-industry interface for engineering schools (23). Now environmental issues by their nature call for the diffusion of understanding both from and into our educational institutions. Without such

mutual diffusion there can be no long-term intelligent concern for development and the environment. All the mechanisms of intersectoral exchange - co-operative education, staff exchange, graduate internships, co-operative studies and research - are essential to the generation of awareness which, as Dr. Hare has commented, is a desirable precursor to the formal manipulation of curricular content. The development of awareness can be tackled within the scope of any institution and set of resources.

The orientation of general instruction

I now postulate that the process of generating an augmented level of awareness among staff within an engineering school is underway and that the practical issue of instructional processes is to be faced. Again I would note that questions of the education of environmental specialists are not at issue.

A recent major multidisciplinary study of critical environmental problems on a global scale has the following observation (24) to make on the issue of professional education as a whole:

> ... A sensitivity to the relations between the processes of production, distribution and consumption on the one hand, and the processes of pollution on the other and a disposition to explore all the potentialities of technology and organization in the search for an optimal balance should be incorporated in their training. This applies to economists, lawyers and social scientists as well as to scientists and engineers...

The overall scope of this observation can be endorsed but for purposes of engineering schools I would place a stronger human emphasis on technology and man as explained in the previous sections of this paper. As George Bauer suggested in De Re Metallica over 400 years ago, production, distribution, and consumption are instrumental processes for human development not ends in themselves.

The structure of technology

All students of engineering should have some appreciation of two basic developmental questions which are related to the structure of technology and have answers conditioned by socio-cultural history. In terms of technological development the questions are: where are we? and how did we come to be where we are? Interpretation of the first question may come out of the career experience of staff and the kind of "regional appreciation programme" which I espoused in the preceeding section. Interpretation for the second question must come from the study of socio-economic history including the study of how technology and its control has influenced regional development. The structure of technology should be examined from a variety of viewpoints.

From a social viewpoint, Mumfor, (25), for example, has identified what he calls mutant, dominant, persistent and remnant elements. From an engineering view one may distinguish available, asymptotic, innovative and provident technology. Asymptotic technology is that for which the operating functional principles are well known, for example of steam turbines, and the continuing development process consists in refining designs and enlarging sizes usually in response to the principle of economy of scale. Economy of scale is a major influence in shaping the structure of the technology of actively industrialized nations and has a significant impact on the ecosystem. Provident technology is that which is anticipated at some time but is as yet unattained, for example controlled fusion.

With respect to the structure of technology and the environment the issue of sensible sizes is pertinent. The teleonomic processes of nature have placed man in the middle between entities on the cosmic and nuclear scale. ~~Form and growth~~ (26) in animals and plants is governed by principles which control scale. Students should be taught to ponder the balance of scales in nature and in human artefacts both for single units and in the sense of populations.

Another categorization of technology that is pertinent to the framework for environmental studies is that of private, public and corporate or industrial technology. The public technology of systems for water supply, transportation and communication is designed to deliver a given service at minimum cost. Corporate or industrial technology is that associated with the design and replication of machines and their products, that is, with machine and product populations (27). Technological populations are a crucial issue as between man and the environment and are closely related to the private technology of consumer goods. But it is essential to note that while consumer goods use up natural resources, persons do not consume other than food. All materials, therefore, flow through a cycle of acquisition, transformation, use, waste or recycling.

For economic purposes, inudstrial activity is often divided into three sectors: the primary sector - (mining, forestry, fishing, agriculture) concerned with the removal of nonrenewable and renewable materials from the earth; the secondary sector - (manufacturing and construction) concerned with adding value to materials to form processed foods, metals, chemicals, etc., and to construct machinery, houses, bridges, roads, etc.; the tertiary sector - (transportation, communications, information processing, distribution, sales, health care, etc.) concerned with delivering services to the society.

In summary, students should be made aware of different structural characteristics of the technology of their country from other than a narrowly specific view of chemical, electrical, mechanical, civil or metallurgical engineering. It is the overall regional structure of technology that provides a perspective for sensitivity to questions of environmental balance.

Instructional processes

In coming to a discussion of instructional processes for developing in engineering education an underlying sensitivity to environmental questions, I would like to distinguish between context and content. The context should be based on the concept of systems (28-30) and their structural evolution while the content will be determined by specialized needs and available skills. Engineering has contributed fundamental approaches to the study of communication systems, feedback control systems and systems of industrial processes. Many of these system concepts have now been appropriated by economists (30) and others for use in environmental studies.

Since interconnexion and interdependence are fundamental ideas in engineering analysis, it is natural to extend the boundaries of systems to include the larger socio-envrionmental framework in which technological sub-systems are embedded, and to consider the associated historical aspects of evolutionary development. Society is a result of the design of history whereas a machine is the result of the design of engineering. What has been almost totally absent in engineering education has been a sensitivity to the history of technological development and consequently to the consequences of such development in terms of accumulating social and environmental impact. If the processes of instruction encourage the acquiring of this sensitivity, the methodology of engineering systems analysis will be found to be the natural vehicle for articulating it within the hard core of engineering education.

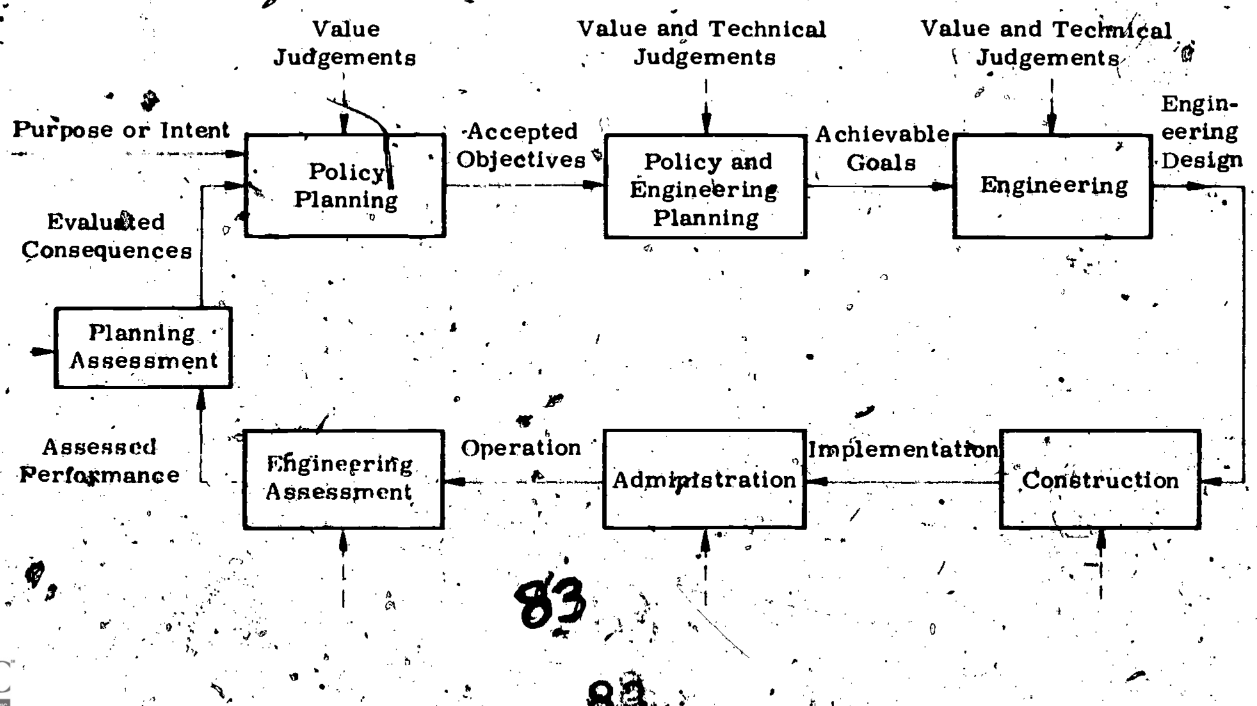
I therefore specifically recommend that engineering educators collaborate with historians, economists, ecologists and sociologists to produce new undergraduate subjects of instruction for all engineering students which combine with conventional history (based on political and social institutions) an appreciation of the structural evolution of technology and of its impact on both society and the environment.* If aberrant and general instances of pollution are not to be attacked, either verbally or by engineering action, in an atmosphere of crisis, it is essential to be aware of the socio-technical processes that lead to the problems in the first place. Study of man and his environment cannot leave out history. In relation to our environment, it is as important to ask - where are we? and how did we come to be here? - as it is to ask - where are we going?

An appropriate stage for students to receive instruction on Regional Technological Development and the Environment is at the beginning of the third year of a four year undergraduate programme. It is essential that such instruction not be superficial. The key ingredients are a small team of vitally interested staff with a leader who may be an engineer, historian, economist or ecologist. In the author's view there is a unique opportunity for Unesco and UNEP to collaborate in generating resource materials for such subjects and I would relate this process to the regional awareness programme to which I referred earlier in this paper.

The systems aspect of engineering education I have been discussing is concerned with context, with a framework of values in an evolutionary structure. But engineering education at the core is a framework for action which can be characterized by the feedback loop shown in Figure 1. This diagram shows the

(*) While there is a growing literature on the history of technology and engineering (31), and there is a great flood of books on man's relation to the environment, there appears to be little that melds historical, technological and environmental influences into the kind of synthetic treatment needed in engineering education.

Figure 1. The System Feedback Loop of Engineering



characteristic sequence of transitions from stated purposes to accepted objectives, to goals considered to be achievable, to engineering design, to implementation, to assessment of performance, and to evaluation of consequences which produce a delayed impact on the articulation of future accepted objectives. The key ancillary input at each stage (represented by the dotted lines) is the scope of the technical and value judgements used in making the transformation involved. If the sequence of judgements is narrowly technical, the loop is small in diameter and may then represent the production of a clearly defined technical component of a more complex machine. The acceptable consequences are good technical performance. If the sequence of judgements is broad in scope and considers socio-environmental issues, the acceptable consequences include not only engineering performance in the technical sense but also environmental impact. The sequence of decision and operational stages in Figure 1 is applicable to devices and indeed to whole complexes such as transportation systems.

In engineering education as I have known it, the above loop is rarely traced out except in project design work and possibly theses. To paraphrase Dr. Hare's words, rarely does the teacher stand back and speculate about the significance of what he is proposing in other than a narrowly technical and immediate sense. The sciences and engineering sciences in the engineering curriculum are instrumentalities of engineering purposes and not ends in themselves. But the student experiences them too often as ends, and projects and designs are often isolated from larger questions of significance and intent.

I would not propose that in all projects and design work the loop be closed on a basis of broad environmental concern. Such a procedure would lead to superficiality. What I do propose in every area of engineering education is that the teacher point out to the student at what level of judgement the underlying decision sequence is being developed and therefore point out what levels of judgement are being omitted. Concentrating on issues relevant to the task at hand is essential to good engineering, but many of our problems stem from relegating to the unconscious the factors that have been so set aside.

Since every field of engineering impacts the environment, it is essential for every engineering student to participate in at least one engineering design or project study in which the level of judgement used in following the decision sequence of Figure 1 includes explicit concern for socio-environmental effects. The ways in which this can be done are as various as the qualities of awareness present in the teaching staff and depend critically on this quality.

Projects (32) should be derived from the regional environment in which the engineering school is located. These may, for example, be based on mass and energy balances for processes, industrial plants, agricultural, forestry and mining operations, and population centres; on tracing the pathways in the local ecosystem followed by materials involved in mass balances; on organic system models for transportation, communications and energy services in a region. The organic view should include an examination of how government regulations, taxation policies and regional development policies influence the evolution of the subsystem being considered.

In technical schools, projects may be built, for example, around the instrumentation and monitoring of mass and energy flows related to soil, water, air and associated technological operations. Environmental problems offer a unique opportunity for project groups to be set up jointly within engineering schools and between engineering schools and technician schools with the collaboration of local government and industry.

The development of teaching resources

Each school should have a modest information centre designed to support studies of regional problems of the environment associated with regional technological development. This may be incorporated into the library by careful cross-referencing. The documentation should include government (18) and utility reports (33), annotated bibliographies (22, 34, 35), periodicals (36), review articles (37) and film lists (38, 39). These materials should cover the rôle of science, engineering and technology, of taxation (economics) and of government regulations and development policies. Much of the existing material generated in intensely industrialized countries will not be particularly relevant to a specific regional focus. It is, therefore, recommended that the format of information files necessary for the achievement of a balanced regional focus be defined as part of the proposed regional awareness programme, and that Unesco and UNEP develop guidelines for such information files.

Beyond the development of the structure for such information files, there may be commissioned the preparation of regional documentary assessment guides which would function as extended annotated bibliographies for environmental references. Unlike many textbooks which are written by individuals in the context of the teaching programme of a single institution, this work should be carried out by a task group of teachers, government and industrial representatives led by an able individual. This proposal is intended to place emphasis on the need to interpret the vast flow of accessible information in a regionally significant manner, a task that in itself has distinctive value. The commissioning of such interpretive studies should be effective in delineating where specialist texts and films are badly needed.

No effort to develop sensitivity to the environment in an engineering school as a whole can be successful without a reasonably widespread commitment from the teaching staff. In schools that have civil and/or

chemical engineering departments, basic leadership may be expected from these groups. However, a task group with an able leader and at least one staff member from each area of engineering may be essential as a catalytic and coordinating influence. It is desirable that such a group, founded within a school have, as full or associated members, persons who can provide insight from ecology, economics, law and history and from government and industry. When the framework for awareness is not just environmental problems, but the historical interplay of regional technological development with environment, the great majority of the staff and students should be keenly motivated.

Conclusion

This paper has been concerned with the need and workable processes for achieving in engineers and technicians as a whole professional group sensitivity to, and awareness of, environmental problems. It is argued that such an overall need is real and therefore that separating out environmental concerns and allocating them to a new disciplinary branch of engineering called environmental engineering is not feasible. All engineers and technicians must be concerned, aware and educated to act, some more than others. This is not to argue that in a given region one or more schools should not specialize in environmental studies. However, it is to argue that an overall awareness should be developed in all schools and be selectively intensified in ways that are discussed in the papers companion to this. For many students selective intensification may consist in having the opportunity to take one or more elective subjects on ecology, technology and the city and so on, which are additional to the proposed core subject Regional Technological Development and the Environment.

A key argument in this paper is that environmental concern should be integrated into an appreciation of how technology has developed and may be expected to develop in the region. To achieve this end, threads of historical regional development - social, technical, economic, environmental - must be woven together in ways which are not at all common in engineering education as it now exists. The historical evolutionary structure of regional technology and its impact on people is a key ingredient. It is this proper concern for the creative rôle of engineering in social development that will motivate staff and students alike.

No prescriptions have been given for curricular content as such. Such content will flow from specialized sources readily enough if the context of environmental study in the school is developed through a regional awareness programme led by a task group working from the available base of staff skills and other resources. The author reaffirms his conviction that there are unique opportunities for Unesco and UNEP to stimulate such coherent awareness and in so doing to revitalize engineering education.

The context of the arguments applies to all professionals similar to engineers.

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Annex VI

THE EDUCATION AND TRAINING OF ENGINEERS FOR ENVIRONMENTAL HEALTH

Paper presented by the World Health Organization

I. INTRODUCTION AND PURPOSE

The close relationships between environment and health have been increasingly recognized and stressed in recent years in all parts of the world. As the Twenty-Seventh World Health Assembly noted, "any environmental deterioration ultimately affects human health and any programme for the improvement of the environmental ultimately contributes to the improvement of human health and well-being". The economically developed nations are facing acute problems of environmental pollution caused mainly by chemical and physical contaminants of water, air, soil, food, habitat and work place, while in most developing areas biological contamination will remain, for many years to come, the main problem of environmental health, although other types of pollution are rapidly increasing also and need to be controlled before they get out of hand. In both instances the solution of the environmental problems involved requires the application of engineering principles to (a) the prevention, control and management of environmental conditions that adversely influence man's physical, mental and social health and well-being, and (b) the work and processes involved in the improvement of the quality of the environment for man's health, comfort and efficiency.

The reader's attention is called especially to the fact that health, according to WHO's Constitution, is not merely the absence of disease and infirmity but also a state of complete physical, mental and social well-being. The expressions "health" and "environmental health" used in this paper must be understood in this context and do not refer only to a disease-oriented concept. The ultimate objective of the environmental work of engineers in many cases is man's health and well-being, even though intermediate objectives may be limited to the actual control or modification of specific elements of the environment. It is obvious, therefore, that engineers belonging to several fields contribute directly or indirectly, singly or through teamwork, to the fulfilment of the health objective.

This view is shared with several WHO expert committees and with authors of WHO publications and reports, including:

1. The report of the Expert Committee on the Education of Engineers in Environmental Health. Techn. Rep. Ser. 376, 1967, pp. 6-8.
2. The publication entitled The Education and Training of Engineers for Environmental Health, Cassel, J. et al., 1970, pp. 11-14.
3. The report of the Expert Committee on National Environmental Health Programmes: their planning, organization and administration, Techn. Rep. Ser. 439, 1970, pp. 18-19.
4. A paper on "WHO's interest in environmental health" presented at Unesco's Expert Meeting on Environmental Engineering, Paris, 21-25 January 1975.

These documents have been distributed to all participants in this meeting, and it is not proposed to review them here. Special attention is called, however, to the excellent discussions of "Environmental health engineering" by Professor John A. Logan, and to "Changing concepts of environmental health", by John R. Goldsmith, in publication No. 2 (by Cassel et al.) cited above. It will also be noted that Unesco took part in the work of the WHO Expert Committee on the Education of Engineers in Environmental Health (TRS 376), publication No. 1 mentioned above.

The purpose of this paper is to describe in some detail the rôle of the engineer (whether called public health engineer, sanitary engineer, environmental health engineer or simply environmental engineer) in health-oriented work, and the principles of educational planning which should guide his education and training.

II. ROLE OF THE ENGINEER

Before a suitable education programme may be designed and curricula developed, it is imperative for the planner and the responsible administrators to have a precise idea as regards the work and rôles to be performed by a health-oriented engineer.

A separate paper, entitled "The functions of the engineer in the assessment and control of environmental conditions and hazards that affect man's health", has been submitted by WHO and distributed to all participants. The paper, which is the product of a consultation meeting called by the organization from 29 April through 1 May 1974, gives a rather broad description of the subject. In

more specific terms, the rôle of the health-oriented engineer may be outlined as follows:

Depending upon his background and degree of specialization, the health-oriented engineer plans, administers and co-ordinates environmental health programmes carried out by health and other government departments, by public bodies and private organizations and enterprises. He performs similar tasks to those of a civil, chemical or mechanical engineer, but concentrates on the conception, design, construction, operation, maintenance and surveillance of specialized facilities, e. g. those necessary for the control of the quality of air, land and water resources and of man's personal and working environment, in particular facilities for water-supply, waste-water and solid waste disposal, vector control, healthful housing, food safety, noise control, radiation protection, disposal of obnoxious gases, chemicals, and industrial water, and evaluates the performance of such works. In collaboration with health officers and scientists, he assesses environmental conditions, organizes and supervises programmes for the monitoring and surveillance of the quality of man's environment, participates in the elaboration of statements on expected environmental impact of physical development programmes; carries out research and investigations, assists in setting standards in physical and urban planning and in evaluating adequacy and effectiveness of control programmes and measures for the protection of man's health and well-being. Finally, he organizes studies on related economic, financial, managerial and legal feasibility.

It must be well understood that no one engineer can have an education and competence in all the work areas cited above, and that environmental health programmes require teamwork involving the participation of various types of engineers, public health officers and scientists, all of whom should have, through their education and training, a common understanding of the ultimate objective to be achieved.

III. EDUCATIONAL PLANNING

The challenge brought about by the broadening scope and acceleration of environmental changes, allied to the growing popular concern of pollution problems, raises a series of questions in respect of the training and education of environmental personnel in relation to their rôle in environmental health matters. In recent years, there have been continuous concern and interest in these questions. The consensus of opinion is that to proceed with the production of trained people in the absence of planning is, at best, to display ignorance of the basic aspects of the manpower issue, at worst, to perpetuate a situation which defeats the very purpose for which people should be trained. In addition to stressing the need for systematic manpower planning for the continuing surveillance of manpower requirements, development and utilization, the authors of current literature on the subject argue very forcefully that manpower development should ensue from the modern concept of educational planning. Emphasizing further the common purpose of manpower development and service, these authors argue that manpower and educational planning should be supported by a cohesive and dynamic policy.

It is beyond the scope of this paper to discuss both the aspects of planning and development of the manpower issue. Instead, this part of the paper addresses the issue of educational planning, and, more specifically, that of educational learning objectives, with a view to stimulating its application in the development of environmental manpower that will be capable of contributing to the achievement of human health objectives. Of course, it is not intended, nor is it possible, to define the educational objectives of training programmes for this type of engineer in the context of this paper. Indeed, educational learning objectives are defined on the basics of needs and of the actual tasks which the engineer is called upon to perform. Additionally, educational learning objectives can only be formulated in the context of a given situation, namely country or region. However, the formulation of educational learning objectives is illustrated in Annex II of this paper. They have been developed in connexion with the establishment of an inter-country training programme for environmental health personnel at the technical level. They cover only those activities of sanitation personnel that are related to the surveying of existing sanitary conditions, and are based on the needs and tasks of this personnel, both of which have been predetermined.

A study group defined educational or instructional technology as "a systematic way of designing, carrying out and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication, and employing a combination of human and non-human resources in bringing about more effective instruction."(1) This definition, obviously, includes all the attributes that are normally considered in educational planning.

Viewed as a system, the process of educational planning comprises the essential steps that are common to all systems, namely:

assessment of the real needs that exist;
assessment of resources, including the identification and determination of influences of the constraints or limitations that exist;
definition of tasks;
development of alternatives to achieve the desired objectives, including the selection of the optimum alternative for implementation; and
evaluation through feedback based on collection of information.

This is further elaborated and best illustrated in figure 1 (p. 91).

III. 1 EDUCATIONAL LEARNING OBJECTIVES

In addition to recognizing the interdependency between the elements of the system, all educators and educational planners today agree to single out the definition of educational learning objectives as

a most difficult, yet most essential, step of the process. This assertion is based on the premise that "an educational programme has more chance to be effective if its purposes have been clearly expressed". (2)

What are educational learning objectives? Kemp (1971) defines them by posing the question: "What should students know, be able to do, or in what ways should they behave differently after studying this topic." (3) He argues further that "we speak of learning objectives because our concern is with learning as the outcome of instruction". The very popular fable of the Sea Horse narrated by Mager in the preface of his book Preparing instructional objectives, a classic of the literature on the subject, illustrates best the importance of this element of the system of educational planning. "The moral of this fable," in the author's own words, "is that if you're not sure where you're going, you're liable to end up someplace else - and not even know it". (4)

Articles on both educational planning and learning objectives are being published in increasing numbers. Unesco has promoted the publication of a whole series of booklets that are "written primarily for two groups: those engaged in - or preparing for - educational planning and administration, especially in developing countries; and others, less specialized, such as senior government officials and civil leaders, who seek a more general understanding of educational planning and of how it can be of help to overall national development". As early as 1969 a WHO internal document (Handbook for teachers of health sciences, (AFRO) disseminated information on the subject.

In the specific field of engineering education, the American Society for Engineering Education plays a leading rôle in disseminating information on the subject. Of particular interest are a series of articles published by the Society in the December 1972 and March 1974 issues of their magazine Engineering Education. The Third National Environmental Engineering Education Conference, held at Drexel University in August 1973, recommended that the topic of educational learning objectives, including the use of newer educational methodologies to meet these objectives should be appropriate for a workshop to be sponsored by the Association of Environmental Engineering Professors (AEEP). (5)

III. 2 THE CONCEPT OF ORGANIZATION DEVELOPMENT

In the context of this discussion, and in order to emphasize further the common purpose of manpower development and service, it is appropriate to bring forth a "new trend", that of "organization development". The trend is defined by Burke and Schmidt as "a process which attempts to increase organizational effectiveness by integrating individual desires for the growth and development with organizational goals". (6) Basically, the concept of "organization development" stems from the new meaning of the terms education and training, and relates as well to the relevancy of the educational learning objectives to the organizational institutions in which the trained people are called upon to work. It is an important factor in the "man-organization" equation.

Training and education, today, imply "a planned change over a period of time in the behaviour of the learner". They entail much more than the development or improvement of skills. Behaviour is interpreted as meaning evidence of "development" in three domains, affective, cognitive and sensory/motor. Therefore, the success of an educational programme depends on the outlook of its graduates and can be measured by their standards of performance, i. e. whether the students have acquired the knowledge, attitudes and skills required by their future assignments. But, above all, the success of an educational programme depends on whether, once trained, people will be able to work in a "growth milieu" or an organizational environment which motivates them, stimulates their talents, and acknowledges the personal goals of its members and - as best stated by Byers - "the need to bring these goals in as close consonance as possible with organizational goals". (7)

Obviously, the latter objectives cannot be accomplished by the educational programme; instead, they should be contemplated in a second phase to be executed jointly by the educational institutions and the organizations within which the graduates will exercise their profession.

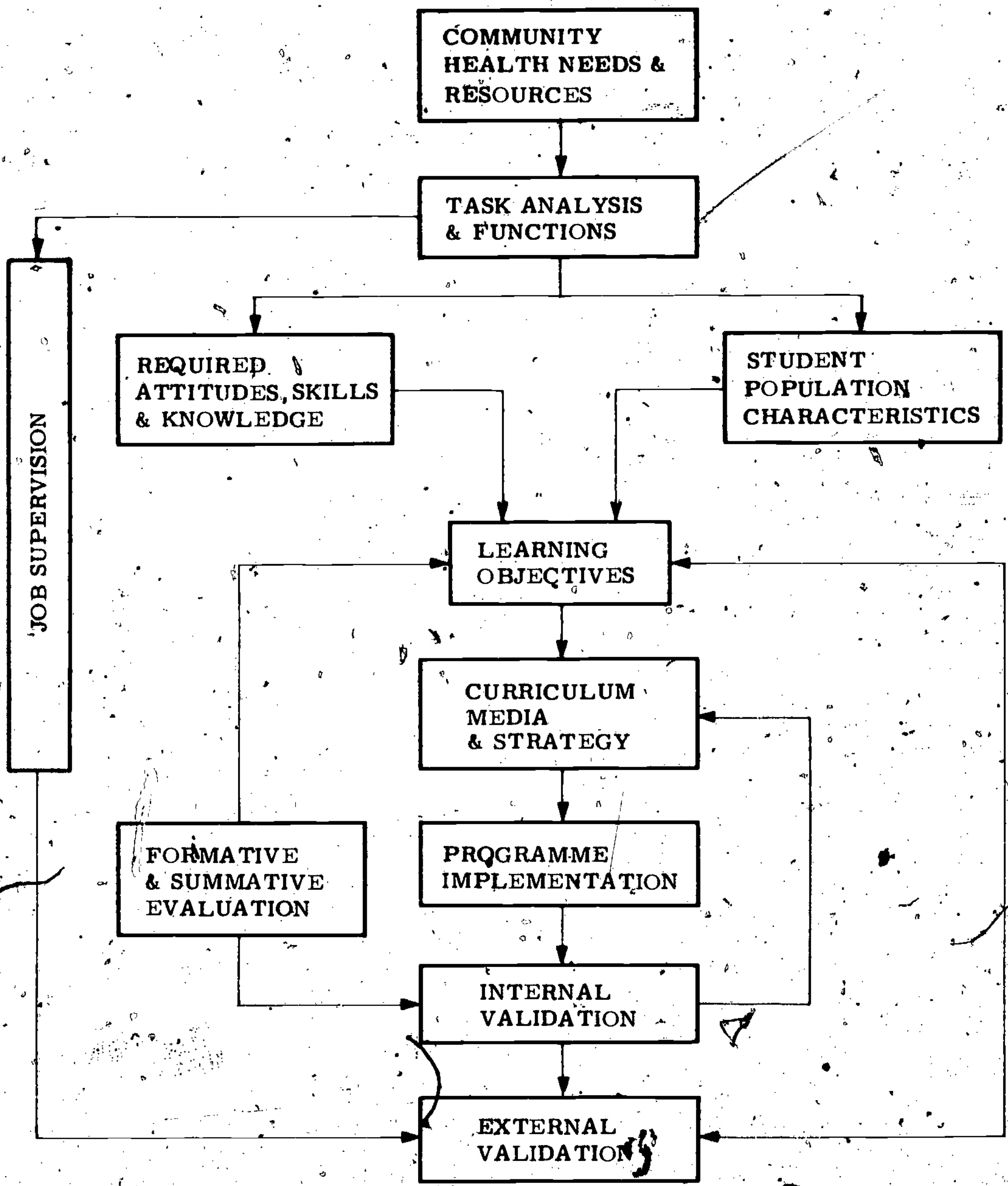
In effect, the whole applicability of "organization development" in the educational system is not in technique as much as in attitude. The concept really involves more of a philosophy than a methodology, and because philosophies have been historically either extremely vague or almost prohibitively involved morally, few of them have succeeded in a large context. However, the establishment and partial success of some worldwide programmes allude to the possibility of more than localized survival of the "organization development" concept.

III. 3 WHO's ASSISTANCE TO EDUCATION AND TRAINING IN ENVIRONMENTAL HEALTH

The prospects for significant changes in the WHO programme of assistance in education and training are evident in several World Health Assembly resolutions and recommendations of WHO Expert Committees (TRS 376, TRS 439). In acknowledging further the new trends and developments in the educational field as they apply to engineering education, WHO has launched several activities, all of which reaffirm the Organization's progressive interest in environmental health engineering education. Some of these activities which, of late, have been undertaken by WHO include: the long-term programme in environmental health which comprises a strong element of education and aims at the establishment and support of a number of centres for the training of environmental health personnel, similar to the already established Inter-regional Sanitary Engineering

Centre in Rabat, Morocco; the study recently initiated by the WHO Regional Office for Europe, the primary objective of which is to survey environmental health manpower requirements, as a basis for evaluating current training programmes and preparing new ones; the organization by the WHO Regional Office for South East Asia, in November 1973, of an inter-country seminar on the subject of manpower planning, development and utilization in environmental health; the organization of a workshop which is planned to be held in Rabat, Morocco in October 1974 on the theme; use of new methods and techniques in educational programmes for various levels of environmental health personnel, especially their use in sanitary engineering courses. In addition, WHO is actively engaged in the elaboration of a comprehensive global programme for the development of environmental manpower, in response to the World Health Assembly resolution WHA26.59 adopted by the Assembly in May 1973. The overall objective and sub-objectives of the programme are detailed below.

FIGURE 1



OVERALL OBJECTIVE

To assist Member States to prepare and implement their plans for providing the staff to man their environmental services

It would have the following sub-objectives:

A. Formulation of manpower and educational policies and plans

To promote studies and investigations with a view to developing practical working guidelines required for the formulation of manpower and educational policies and plans.

B. Determination of manpower requirements

To extend assistance to Member States in determining their manpower requirements in the context of their national health plan and programmes.

C. Development of manpower and educational planning

To assist in strengthening existing national, regional and inter-regional educational programmes and in the establishment of new programmes, to include:

manpower planning for the continuing surveillance of environmental manpower requirements, development and utilization, and

educational planning to include basic and continuing education, research (as a component of teaching/learning), educational technology and evaluation,

thus emphasizing the common purpose of manpower development and service in environmental health.

D. Improvement of the quality of education and the educational delivery system

To assist in the establishment of international and regional reference services, and in the organization of workshops, seminars and other meetings for the exchange of knowledge and information, the preparation of handbooks, the promotion of research on educational planning and technology, in order to improve the quality of education and the educational delivery system.

E. Teacher training, training of specialists

To organize or assist in the organization of long-term and short-term courses and multi-professional education courses for teacher training and the training of specialists in human ecology and environmental sciences and technology.

Definition of educational learning objectives

The following objectives, which are defined in behavioural terms, are those related to one of the primary functions of sanitation personnel, namely, the carrying out of services and investigations regarding existing sanitation conditions in the area of his assignment. Additionally, the predetermined needs are those in water supply, excreta disposal, food hygiene, insect and rodent control and housing.

Water supply

To carry out an inventory of water resources, that is to identify all water sources and the use that is made of them; to localize them on a map of the area of work; to indicate the extent of pollution and the topographical characteristics around each water source and within a radius of 50 metres.

Describe the physical characteristics and pattern of utilization of water; whenever possible, determine the yield of the water source.

Excreta and other wastes disposal

Describe the different methods of excreta disposal that are actually used, including the capacity of septic tanks, the size of concrete slabs of pit latrines, the existence or absence of odours, flies, rodents or others.

Determine approximately the number of people using a latrine and the frequency of utilization.

Describe the topographical characteristics of the area where latrines are situated and the distance of excreta disposal systems from water sources.

Identify those areas where defecation is practised in the open and the physical characteristics of such areas in relation to water sources, residential areas, public markets, etc.

Determine the composition and approximate volume of household refuse.

Describe the methods of disposal of refuse, the sanitary conditions of disposal areas, etc.

Food hygiene

Describe the sanitary conditions of places where foodstuffs are stored, prepared, sold and consumed, and in particular those of public markets, restaurants, etc.; methods of transport of foodstuffs; methods of controlling the quality of meat and milk; the sanitary conditions of slaughterhouses; the conditions under which milk is handled and sold.

Insect and rodent control

Identify insects, molluscs and rodents, with particular reference to those that are implicated in disease transmission.

Determine the physical characteristics of marches or other places where water stagnates, breeding place for insects and rodents, and localize these on the sanitary map of the area of work.

Housing

Describe the types of housing in the area of work, including the characteristics of the terrain on which these houses are built; the construction materials that are used in the floors, roofs and partition walls.

Describe the sanitary conditions of housing in respect of aeration, ventilation and the number of people using the sleeping quarters.

Indicate the methods of water supply to the premises and methods of storing water for drinking purposes; methods of excreta and refuse disposal, etc.

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ENVIRONMENTAL ASPECTS WITHIN UNIDO's ACTIVITIES IN THE FIELD OF TRAINING

Paper presented by the United Nations Industrial Development Organization

UNIDO organizes In-plant Group Training Programmes for engineers and advanced technical personnel from developing countries in co-operation with the governments and industries of countries having the specialized know-how and experience in the field in which the training is carried out. It is being increasingly recognized that intensive, systematic and closely controlled training in a suitable industrial environment is one of the most effective ways of acquiring industrial experience in a relatively short time. Through these programmes a means has been found providing an experience that might not otherwise be possible.

The programmes help to bridge the gap between the specific requirements of industry and the theoretical knowledge the participants have acquired through their studies. They also provide an opportunity for an exchange of ideas and experience both among senior personnel of industry and research institutes in industrialized and developing countries and among those from the developing countries themselves.

The first in-plant group training programmes were carried out for specific sectors of industry such as iron and steel, electrical, textiles and pulp and paper. Later, programmes on functional subjects - maintenance and repair, standardization, quality control, etc. - were introduced. It is expected that programmes for other industrial sectors and for new functional or specialized subjects will be added.

Each programme consists in general of three major elements: a theoretical introduction, actual in-plant training and an evaluation session during which the participants prepare individual reports appraising the programme and discuss how the newly acquired experience can be applied under the conditions prevailing in their home countries.

UNIDO is responsible, together with the host authorities, for the design of each training programme, the recruitment and selection of participants, an overall evaluation of the programme and follow-up activities. To increase effectiveness, efforts are being made to place the programmes on a long-term basis, where possible, or have them carried out for at least three years in succession.

In 1972 UNIDO took the initiative to organize an in-plant group training programme on environmental aspects of industrial development, which programme was carried out in early 1973 by the University of North Carolina(1). In 1974 UNEP agreed to finance the incorporation of environmental elements in a number of in-plant group training programmes. For four programmes a special paper on environmental aspects has been or will be prepared by a consultant and the subject matter will be introduced in the following programmes: Pulp and Paper Industry (Sweden), Iron and Steel Industry (Ukrainian SSR), Petrochemical Industry (Romania) and Textile Industry (Poland). In a number of existing programmes, the environmental aspects were already included, such as in the programme on Application of Dyes and Chemicals to Textile (Switzerland) and on Management of Maintenance Services (Sweden). The material thus prepared will be used in repeated programmes as well as in training activities (continuous training of practising engineers) carried out by UNIDO in the developing countries themselves.

UNIDO is also the co-operating agency for a number of other projects in the environmental field, namely: (i) environmental considerations in the leather-producing industry; (ii) case studies of four industrial development projects; (iii) study on the development of integrated industrial complexes with minimized pollution; (iv) environmental considerations in the iron and steel industry; and (v) study on synthetic versus natural products - pilot project on the rubber industry. The material developed in these studies will be utilized in UNIDO's field project including training projects both in the developing countries themselves as well as in the in-plant group training programmes referred to above.

In order to assist the developing countries with information on industrial development, UNIDO has established a clearing-house service in the form of an Industrial Inquiry Service, which service is used by industry, industrial institutions and, if so required, by education institutions. In 1973 the UNIDO Industrial Inquiry Service, processed 3,500 answers; of these 20% were related to equipment, 50% to technologies and 30% to

(1) For further details see Annex V, paper by Professor Okun.

statistics, programming, management and training. The Industrial Inquiry Service is also prepared to provide interested parties in the developing countries with information on environmental aspects related to industry. Information is supplied from UNIDO's own sources as well as from a network of correspondents in different countries, both industrialized and developing countries.

WMO ACTIVITIES RELATED TO AIR POLLUTION

Paper presented by the World Meteorological Organization

1. In view of the possible unfavourable consequences of a gradual increase of low-concentration pollution in the atmosphere, there is a great need for a world-wide monitoring system to follow the trends of atmospheric pollution at a background level. With this in mind, WMO decided in 1970 to launch a project aiming at the establishment of a global network of observation stations to be located sufficiently remote from industrialized areas so as not to be influenced by fluctuations in pollution from local sources. It was agreed that, to meet the WMO requirements, the network should consist of two types of stations with distinctly different objectives:

(a) Regional air pollution stations, intended to reveal long-term changes in atmospheric composition which may be related to changes in regional land-use practices or other activities.

(b) Baseline air pollution stations, designed to document long-term changes in atmospheric environmental parameters of particular significance to weather or climate, with a minimum influence from local or regional factors.

2. As regards the first type of station the network became operational in July 1970. Since that time and as a result of a request to all members to establish at least one regional station in their territories, the network has been expanding and now comprises some 90 stations from 42 countries. It is hoped that in the next few years this network of stations making measurements of the atmospheric composition will grow to 150 stations.

3. Concerning the second type of station continued interest is being devoted to establishing such a network. So far, nine members have proposed locations for altogether 18 such stations. It is currently estimated that finally about twenty stations of this type, well distributed over the surface of the globe, will meet the spatial sampling requirements to allow studies of long-term global trends in atmospheric composition.

4. An arrangement has been made with the United States of America who have volunteered to collect and publish, under WMO sponsorship, the "Turbidity, and precipitation chemistry data", in accordance with mutually agreed upon formats and standards.

5. In order to achieve the standardization and comparability of the data from the network, a manual is being prepared, giving detailed specifications for the operation of the stations and step-by-step instructions for recommended sampling and analysis procedures. Part I of this manual "WMO Operations Manual for Sampling and Analysis Techniques for Chemical Constituents in Air and Precipitation" gives advice and describes the programme for regional stations. Part II which is to present guidelines on sampling and analysis techniques for gaseous and particulate matter in air at baseline air pollution stations, is now being prepared with the collaboration of several eminent scientists. It is expected to be published in mid-1974.

6. WMO is increasingly aware of the need to study man's impact on global climates through various activities. The United Nations Conference on the Human Environment in Stockholm in 1972 in fact recommended WMO, in co-operation with the scientific community, to continue ongoing programmes or create new ones as necessary to study the consequences for the world's climate of man's increasing impact. The Global Atmospheric Research Programme, a common enterprise of WMO and ICSU, has already taken steps to organize a special international conference on models to be used to study climatic fluctuations and man's impact on global climates. Various other activities for promoting research on climatic fluctuations are likely to emerge.

7. WMO, although especially interested in background pollution and its effect on climate has also considerable activities going on in relation to problems of high-concentration air pollution. A working group on atmospheric pollution and atmospheric chemistry of the Commission for Atmospheric Sciences has prepared a technical note on meteorological aspects of high concentration pollution in local areas which deals with transport and dispersion in urban environments and forecasting techniques for atmospheric pollution applications. The title of this note is "Dispersion and forecasting of air pollution".

8. As is well-known, engineers need to know how high to build chimney stacks and health authorities need to know when the amount of pollution is likely to build up to a certain critical level. The height of the chimney stack is determined by the height of the inversion level in the atmosphere and

the temperature of the stack effluent. Meteorologists can be of particular help in air pollution control programmes by providing forecasts of the atmospheric parameters that permit the build-up of pollution. These are called forecasts of "air pollution potential".

9. A more popular review of meteorological problems in connexion with high-concentration air pollution and their treatment has also been published by WMO under the title "Meteorological factors in air pollution" (Technical Note No. 111).

10. As far as consequences of air pollution are concerned, it is necessary to consider also the problem of dispersion of pollutants over comparatively large areas so-called long-range transport. There are many evidences today that emissions of pollutants from highly industrialized areas may spread over comparatively large distances thereby influencing atmospheric conditions in other countries or other continents. Transfer through the circulation of the atmosphere of emissions of SO_2 from industrialized areas could increase the acidity of rains and cause in turn raised acidity in inland waters and soils far away from the area concerned. The WMO network of regional stations to monitor background air pollution may ultimately provide data suitable for investigations of such regional dispersion of pollutants.

11. Climatology must also play an important rôle in planning the appropriate use of land in relation to air pollution meteorological potential. In planning cities, industrialization, agricultural activities and resort areas, it is essential to establish in advance, by means of climatological data for relevant meteorological parameters, the probabilities for air pollution to occur taking into consideration emission factors as well as topographical and other local conditions. Climatologists in meteorological services have been urged to take on such investigations and a rapporteur of the Commission for Special Applications of Meteorology and Climatology is now preparing international guidelines on the techniques to be applied in such investigations as well as listing those meteorological parameters which need climatological treatment.

12. Finally, in discussing possible consequences of air pollution it should not be forgotten that effects of air pollution could have a considerable impact on agricultural activities. A WMO Technical Note No. 96 - Air pollutants, meteorology and plant injury - points to the established damage to plants of air pollutants and the very close relationships between air pollution and the world's food supply are also discussed.

13. At present WMO is currently engaged in various studies related to atmospheric pollution. A WMO Executive Committee Panel of Experts on Meteorological Aspects of Atmospheric Pollution has been entrusted with this task.

ICSU ACTIVITIES

Paper presented by the International Council of Scientific Unions

The International Council of Scientific Unions has several groups which are involved in the environmental aspects of education and training of engineers. The Committee on the Teaching of Sciences organized, in collaboration with Unesco, a Conference on Integrated Teaching of Science in Maryland in 1973, which was concerned with teaching science for today's and tomorrow's society. The Conference was essentially concerned with the development of teaching methodology and curricula, the use of which would develop scientific attitudes for use in decision making, give an indication of the impact of science and technology on society, and of the impact of man on science, technology and his environment. Part of any such integrated teaching would involve developing a student's awareness of the environment in which he lives and of the ways, both detrimental and beneficial, in which man is modifying it.

The Scientific Committee on Problems of the Environment (SCOPE) is developing a programme which will advance knowledge of the influence of human activities upon the environment and the effects of the resulting changes on human health and welfare. The subject areas of primary interest to the meeting are rational management of natural resources; simulation modelling; environmental education and training. SCOPE is also examining the possibilities of establishing an environmental impact assessment system. The assessment would identify the activities responsible for the impacts and the impact receivers, both natural and man-modified. A recent workshop dealt specifically with the principles and methodology of environmental impact assessment.

SCOPE Report 2, "Man-made lakes as modified ecosystems", is a case study of human experience in major ecosystem modification using man-made lakes as an example. This study provides an excellent illustration of the environmental effects of a major engineering development, and includes consideration of such effects on the earth's crust, on the biology of the water masses both behind and below the dam on the hydrology, on the meteorology, on the people affected, on public health, and so on. The report also makes some suggestions with regard to the requisites for modelling.

The environmental aspects of education and training of engineers could be improved by the use of a series of such case studies covering the major types of important engineering works such as dams, harbours, air fields, urban complexes, transport systems, etc. These case studies could be used in courses and seminars, could form the base for practical studies in workshops, and could be graded in complexity so as to meet the educational needs of high school and university students, managers and policy makers.

It is suggested that the publication of appropriate case studies, both prior to and after completion of the construction, in the most frequently read engineering journals, including details of the types of experts that might be involved would draw attention to the multidisciplinary requirements of such case studies.

THE TECHNOLOGY OF THE ENVIRONMENT, THE ENVIRONMENT OF TECHNOLOGY

by
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I. INTRODUCTION

For a number of decades now the modern world has been engaged in a process of scientific and technological transformation, the pace of which increases from day to day.

Because of their effectiveness, science and technology are opening up vast fields for human endeavour while others, as yet unsuspected, are still to be revealed.

The progress of science and technology had, however, been the result up to now of extremely piecemeal decisions, of a more or less haphazard kind, and largely taken in ignorance of their real import. To a great extent, these decisions have been based, furthermore, on very summary aims of subsistence or domination. The combination of these two facts has ended by bringing about changes that in many sectors today are seen to be catastrophic. This is the case in particular of the impact of industrialization on the environment. We see the increasing apparition of flagrant symptoms of overstrain in the mechanisms for renewing the resources of the biosphere symptoms, which point to the occurrence of irreparable damage.

The rate at which tropical forests are disappearing, for example, has become such that almost total elimination in a relatively few years' time is easily imaginable. The spreading of the desert by inappropriate tilling and grazing policies, coupled with extremely adverse climatic conditions, is condemning an increasingly large proportion of the African population in the Sahel zones to famine and death. The vast urban agglomerations are faced with pollution problems that are rapidly becoming intolerable: air pollution through carbon monoxide, mainly caused by road transport; noise pollution from the same source; pollution produced by the excessive concentration of electro-magnetic waves resulting in the undesirable overheating of living cells, etc.

Water resources are another main cause for concern. The harnessing of such resources by the construction of great dams has brought about changes which are sometimes disastrous to the ecosystems of the environments in which they have been sited. The systematic and thoughtless disposal of human waste in inland water with no outlets has led not only to deterioration in the quality of water for domestic use but also to disappearance of the animal and vegetable species which have developed in them for thousands of years.

There are endless examples which all point to the accelerated decline in the quality of the environment. We are thus faced by this paradox that it is, in fact, the introduction of science and technology in the social, political and economic life of the nations, aimed at improving the quality of life, that is largely responsible for its deterioration.

In order to destroy this vicious circle, part of the research and development effort - a still modest proportion - is being devoted today to remedying the disastrous effects of industrialization. The "technology of the environment" is making praiseworthy progress, which reflects the concern of the world community for a more human way of life. Quantitative growth is being replaced to an increasing extent by growth of a more qualitative kind.

In order to speedup this movement, the United Nations Conference on the Human Environment, held in Stockholm in June 1972, stressed the need to make the "decision-makers" aware of the problems of the quality of the environment. Among such decision-makers are scientists and, more especially, engineers who should be associated more effectively in this movement in defence of the environment, not merely by inviting their assistance in the development of new techniques for the restoration of the environment, but by leading them to fresh thinking on science and technology in the light of the impact that they may have on the environment. This is what may be termed "the environment of technology".

There is no doubt that if the guiding of development by science is to be more productive in improving the "quality of life", the whole of society must lend its assistance. But engineers bear responsibility of a special kind.

Among the university-trained executives required by the national production machine, the engineer holds, in fact, an important place in modern society. In the factory where he works, in the society to which he belongs, he represents one of the main points of impact of scientific

and technological transformation on the national substratum.

Because of the concentration of science and technology that he makes possible, the engineer affects - or can affect - the structures and techniques used in decisive fashion so as to give them greater effectiveness and operative force within the context of the new general aims that the world community is beginning to assign itself.

This indicates the great importance of the part which environmental problems should play in the training of the engineer.

This part obviously varies according to the stage of development reached by the country which the engineer is called upon to serve, but it cannot be dispensed with altogether. Indeed, although it is obvious that in many under-equipped countries the immediate problems - virtually of survival - must necessarily occupy the economic planners to a far greater extent, so that protection of the environment takes very much lower priority, it is a fact none the less that decisions taken both within national frontiers and outside them can decisively affect the ecological situation in the country and, ultimately, its very survival.

Conflict has often existed in the past, moreover, between short-term and long-term interests. Survival today may thus very well mean tomorrow's destruction. It is therefore important, even in situations of scarcity, that ecological factors should be fully appreciated and taken into consideration in the application of technology.

The case of the East African high plateaux can serve as example. The great population density in Kenya, Ethiopia, Uganda and, to a lesser extent, Tanzania has resulted in over-utilization of the land with a marked influence on the vegetation of the high plateaux lying at an altitude of over 1,500 metres. The demands of agriculture have led to the destruction of the rain forests in the mountains, resulting in the reduction of water resources. This reduction hastens the deforestation process and even the disappearance of the neighbouring savannah, transforming these regions into deserts.

Even praiseworthy attempts at supplying the semi-arid regions with water have the effect of destroying the productive capacity of the environment and of extending the desert. The installation of a water supply attracts rural populations and domestic animals. The grazing land, always meagre, cannot provide for this inrush. It disappears through overgrazing.

The disappearance of forests and other mountain vegetation has repercussions on the valleys and the plains. Watersheds are destroyed, bringing about soil erosion and the drying up of springs. River discharge is changed, causing erosion of the banks, deterioration in soil fertility, adverse sedimentation in streams, lakes and seas and, ultimately, the destruction of aquatic life.

This example is sufficient to demonstrate the marked interdependence of development decisions and the impact that they may have on the environment and, ultimately, on the very future of the community involved.

II.) THE INTELLECTUAL TRAINING OF THE ENGINEER IN THE ENVIRONMENT SECTOR

But how can we translate these subjects of concern to the world community into terms of a coherent training programme in polytechnical faculties?

It must be recognized, at the outset, that the engineering student's training is of necessity closely related to the stage of development reached by the country he is to serve.

As the situation varies enormously between one country and another and as no country follows exactly the same stages in its economic development as the others that have preceded it, it can be easily appreciated that the same disparity is bound to be reflected in the training provided to engineers throughout the world, and also in the changes that occur in this respect.

But as each country passes through a series of successive stages which are similar or analogous to those through which other countries have passed, we can see that it should be possible to trace an affinity between the different types of training which will lead to the establishment of certain basic guiding principles serving as common denominators.

In regard more especially to the environment and its protection, we have, at the outset, to approach this from the two angles mentioned above: the restoration of the environment by the elimination of pollutants, and the "cleaning-up" of technology itself so that it may become non-polluting. This is the distinction that we have brought out in the title of our paper when referring to the technology of the environment as opposed to the environment of technology.

The second approach lends itself more readily to the establishment of a common denominator between the various training programmes provided in polytechnical faculties.

The "cleaning-up" of technology must begin by a clear definition of the harmful effects of its use. This point of view is seldom brought out when teaching a technique, save perhaps in medical and pharmaceutical schools. A notable exception, however, is nuclear energy. Technical training in this field invariably devotes considerable attention to protection against radiation.

The first thing, then, is to urge that teachers deal systematically with this important aspect of the technical manipulation of the environment.

Needless to say, universities should join together in a sustained research effort aimed at the development of techniques with as little pollution potential as possible.

The "technology of the environment" approach lends itself less readily to the establishment of a common denominator except, perhaps, as far as the listing of the sectors involved is concerned. These can be tentatively set out as follows:

(a) Water resources: development for domestic, industrial and agricultural use; treatment and distribution; sewers, flood control; development of monitoring techniques.

(b) Management of industrial and human waste: recycling; storage.

(c) Air pollution: monitoring and control of pollution; industrial hygiene.

(d) Fauna.
(e) Flora.
(f) Land-use management.

III. THE CASE OF THE REPUBLIC OF ZAIRE

The National Executive Council (Government) of the Republic of Zaire has been concerned with environmental problems from a very early date. Indeed, several national parks date back to the colonial period. The aim in view is to set aside 10% of the national territory as parks.

In Zaire there is, in addition, a National Institute for the Conservation of Nature (I. N. C. N.) which is responsible for watching over the environment. The Ordinance establishing this Institute contains, inter alia, the following provisions: "The I. N. C. N. is responsible for carrying out all studies or research into problems of the human environment such as deforestation, air and water pollution, impairment of sites and erosion.

It shall provide detailed guidance on any industrialization or development project likely to improve or impair the human environment.

For this purpose it shall be notified of the project, at least six months prior to execution."

Specifically as regards training in environmental techniques, it is planned to establish next year at the National University of Zaire (UNAZA-Kinshasa Campus) a degree course in environmental management with the following curriculum:

(a) For graduates in economics, law, civil engineering, medicine and pharmacy

1. Compulsory subjects

General biology, general ecology and quantitative ecology (mathematical method in ecology); geography of Zaire and of Africa; principles of soil science, climatology and hydrology; legislation in regard to the environment; ecological pathology (human influence on the environment and its consequences); management of the environment and rational use of resources.

2. Optional subjects

Hygiene and public health; epidemiology; principles of sociology and economics; animal and plant taxonomy; rudiments of data processing; town planning; principles of hydrobiology; cartography and interpretation of aerial photographs; demography; principles of microbiology; agriculture and economic development.

(b) For graduates in biology and chemistry

1. Compulsory subjects

General and quantitative ecology; further studies in physical geography; climatology; hydrology; soil science; ecological pathology; principles of economics, sociology and legislation in regard to the environment; hygiene and public health; epidemiology; rudiments of town planning; rudiments of demography.

2. Optional subjects

Special aspects of animal and plant taxonomy; rudiments of data processing; further studies in animal and plant physiology; cartography and interpretation of aerial photographs; further studies in microbiology; ecology of land and water ecosystems.

OPTIONS FOR ENGINEERING EDUCATION

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I. BASIC PRINCIPLES FOR THE REFORM OF ENGINEERING EDUCATION

1. Throughout the various fields of engineering, engineering education has been placing too much emphasis on the goal of building things efficiently. From now on, we must also train engineers with an eye toward recognizing and appraising the natural influences and social significance that the results of the application of engineering create. Training in the proper ways of preserving and restoring the social and environmental systems is necessary in all fields of engineering education; the environmental problem is not the technical subject of a special discipline.

2. Dangers to the environment are continually emerging anew. It is not merely modern development that leads to the destruction of the environment, but even the measures taken for environmental protection, as in the case of river basins, can create new problems. Consequently, as a goal for engineering education, it is important to impart on students an attitude of evaluating one's engineering proposals in terms of the environmental system without adhering to preconceived ideas.

3. The environmental problem is not simply the destruction and spoilage of nature, but also encompasses a complex system which is interrelated to the ruination of cultural assets, qualitative changes in communities, and a revolution in land utilization, etc. Hence, it is necessary to take an interdisciplinary approach to education and research on environmental problems in order to obtain a comprehensive view.

4. All engineering activities exert an influence on regional society, and the environmental problems also exists on the regional level. Thus, in terms of the content of engineering education, we must strengthen regional studies by promoting interdisciplinary training that will foster a comprehensive perspective of the situation.

II. THE REFORM OF UNDERGRADUATE EDUCATION

1. In order to deepen students' awareness of environmental problems and to cultivate their ability to comprehend the conditions restricting the application of engineering, the following topics should be treated in classes and open lectures for upper classmen: cartography, geology, geomorphology, ecology, aerial studies, safety engineering, and disaster prevention.

2. We must strengthen educational programmes on environmental problems closely related to established departmental curricula. For example, it is essential to debate and have course offerings on ecology and disaster prevention in departments of civil engineering, mineral-development engineering, and city planning; and on industrial waste disposal and the prevention of air and water pollution in departments of applied chemistry and metallurgy.

3. Various departments are already revising their courses on the environmental problem, and students from other disciplines who have an interest in such matters are structuring their programmes so they can attend these classes.

4. We must establish separate departments, such as sanitary engineering, in those fields like analytical engineering which are already established but where the needs of society are great.

III. GRADUATE EDUCATION AND RESEARCH

1. It is better to treat the environmental aspect of the education and training of engineers in graduate school than on the undergraduate level. The reasons are that:

(a) A comprehensive perspective is necessary in educational programmes on environmental problems, and it is better that both the professors and students be gathered from a number of different backgrounds.

(b) The environmental problem is a new field of study, and it is important to have a system of education that will teach students while promoting research and to recognize that having students do research is an important part of their education.

(c) The result of taking students from all fields of engineering and training them will have a broad, favourable affect on each field in terms of the environmental problem.

2. At this point, I would like to introduce

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the outline of "The scheme for the establishment of a graduate course in environmental science", drawn up at Hokkaido University in 1973, which goes beyond the confines of engineering education and incorporates an interdisciplinary approach involving the natural, social, and humanistic sciences.

(i) Basic principle

This course is constructed with the aims of promoting the multidisciplinary and interdisciplinary research which is the characteristic of environmental science, and of educating appropriately qualified students in this field.

(ii) Organization

With regard to the organization of the course, many opinions were presented, and the following two proposals were examined: A. Structure on the basis of research methodology; B. Structure on the basis of research objectives. The following four major courses and twenty-three chairs were adopted:

A. Environmental structure

1. Basic environmental study: natural history, history of environmental change, biogeography, etc.
2. Environmental climatology: physical chemistry of the atmosphere, urban climate, climatic change.
3. Earth environment: limnology, soil science, topographical change, etc.
4. Ocean environment: coasts, sea surfaces, etc.
5. Land ecological systems: ecosystems, ecological heredity, biochemistry, etc.
6. Sea ecological systems: ecosystems, ecological heredity, biochemistry, etc.

B. Social environment

1. Demography: static populations, population mobility, etc.
2. Human ecology: distribution of settlements, community structures, etc.
3. Environmental medicine: environmental physiology, adaptation, etc.
4. Environmental pathology: poisoning, pollution diseases, social problems, etc.
5. Social psychology: group consciousness, mental hygiene, mass communications, etc.
6. Environmental law: environmental rights, pollution law, environmental administration, etc.

C. Environmental preservation

1. Ecological management: biological resources, preservation of species, etc.
2. Disasters: natural disasters, disaster prevention.
3. Cold-area environment: northern zones - livelihood and products, etc.
4. Landscape: preservation and improvement of landscape, protection of nature, etc.
5. Control of environmental contamination: atmosphere, water, soil, living things, etc.

D. Environmental planning

1. Regional planning: long-term overall planning, land utilization, urban and rural planning, community organization, etc.
2. Environmental transformation: space and ocean development, etc.
3. Resource planning: utilization, management, circulation, etc.
4. Environment of daily life: social welfare, educational planning, etc.
5. Location of industry: regional economics, location theory, etc.
6. Environmental systems: system analysis, prediction, etc.

(iii) Management

In regard to the management of the courses, the following two proposals were examined:

A. In connexion with study, to adopt a "project team" method.
B. In connexion with education, to adopt a common lecture system.

The following methods were adopted:

A. In each major course, to establish a common lecture system, a requirement of which being compulsory attendance for all students.
B. For the acquirement of credits, to establish an optional lecture system, and to allow students to attend lectures outside their special courses.
C. Besides the above mentioned, to establish a "project-team" system (in accordance with draft X), and to promote flexible research activities.
D. To make it possible for students to pursue interdisciplinary research through joining the "project team".

(iv) Strengthening programmes for the continuing education of practising engineers

1. The continuing education of practising engineers is especially important for integrating environmental problems into the various fields of engineering and for giving engineers new insights.
2. For that reason, the first thing that is necessary is that professors and researchers be re-educated by promoting in a positive manner interdisciplinary research on environmental problems. Through joint research, universities and research institutes can continually reproduce fresh educational capacities. I would like to propose as a theme for such joint research the study of regional problems, on which the activities of many of the fields of engineering have an influence.
3. At present, universities have as their system of continuing education master's programmes, graduate researchers, auditors, and

special students. There are also seminars that public and private enterprises conduct. But in Japan, despite the many needs of society, the present university system is not fully utilized. The Government's lead is vital in having public enterprises use the university more for the continuing education of their employees.

4. If we were to hypothesize about the content of continuing education, the establishment of a graduate course for this purpose of at least two to three years would seem desirable.

(v) Primary and secondary education

The persons who are most concerned about the conditions of regional society, where the environmental problems are occurring, and who understand its circumstances are the citizens. Consequently, in order that general citizens may comprehend environmental problems and, if necessary, increase their ability to study technical information, we have to strengthen basic educational programmes on environmental problems in primary and secondary schools.

ENVIRONMENTAL EDUCATION IN INDIA

by
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and
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INTRODUCTION

The need for increasing environmental awareness at all levels of society has been emphasized in recent years in recognition of the fact that environmental problems arise largely from a lack of understanding, on the part of decision-makers, planners and the lay public, of the complexity of natural processes. The Stockholm Conference on the Human Environment recommended effort, both national and international, to promote environmental education which was to be "interdisciplinary in approach ... encompassing all levels of education and, directed towards the general public". An International Congress on Environmental Education is soon to be held by the International Union for Conservation of Nature and Natural Resources (IUCN), in co-operation with Unesco, to evolve methods to promote education in environmental subjects and ways to incorporate these into the national educational systems.

In India too, such a need is being increasingly realized. The structure of our traditional curricula or disciplines do not unfortunately provide the kind of education that is needed, although some courses particularly those connected with life sciences of necessity, contain subject matter which is of relevance to a study of the environment. A number of institutions are keen to reorient their teaching, research and training programmes to include a more comprehensive environmental perspective that will impart the knowledge and skills required for improvement and conservation of the environment.

It is in this context that some suggestions are made below on the possible forms and features of institutional environmental education by itself can achieve very little to promote a general awareness, when the major part of the country's population remains beyond its scope. But in order to keep the area of consideration more specific the focus has been restricted as mentioned above.

Educational needs

Almost everything is a part of the environment and thus, almost every subject is relevant to environmental education. Yet, we can define specific areas of concern which are particularly relevant to our purpose. These will, of course, change from society to society, with circumstances and with the level of education being considered. The IUCN defines environmental education as "the process of recognizing values and clarifying concepts in order to develop the skills and attitudes that are necessary to understand and appreciate the interrelations among man, his culture and his bio-physical surroundings". In simpler terms, environmental education is education "about the environment" that could be used, among other things, "for the Environment", i. e. to understand and solve its problems. This would obviously require a spectrum of knowledge that would go far beyond the confines of any single conventional discipline of science or technology.

The education process should help provide a comprehensive understanding of how the natural world works, of man's dependence on his natural environment and resources and of the ways in which his multifarious activities can preserve or break those links that support and sustain all life on earth. Environmental education must, moreover, include the social and behavioural sciences to provide a fuller understanding of the interactions of man with other men and with nature.

The fundamental need is for a clear perception of the inherent properties of the various components of the natural environment and the linkage between them. It is these linkages which are often forgotten in the monolithic, discipline-based departments of our education institutions. Multidisciplinary courses, textbooks and instruction materials have to be designed to cover this deficiency. Activities like conservation and anti-pollution measures come easily to the public mind and there is the danger of these, undoubtedly significant, areas of study masking the importance of other, less glamorous aspects like the problems of population pressure, human settlements, depletion of resources, etc. This is particularly true of countries like India which share the tremendous environmental problems of poverty such as rapid population growth,

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inadequacy of urban and rural infrastructure, health care, nutrition, etc., together with the more often highlighted ecological disruption that results from rapid industrialization.

Despite the general urge for a non-traditional approach, much can be achieved without any radical restructuring of the existing educational system for environmental education or even the establishment of a totally separate environmental discipline in our universities.

The objectives of environmental education would fit into three broad categories, namely (i) education for orientation; (ii) education for specialization and (iii) education for professional adaptation.

(i) Education for orientation: this would be aimed at creating a general awareness and a sense of responsibility towards the environment among the educated. This would hopefully equip them to judge the effects of actions and policies that would have a bearing on the environment. In other words, the curricula for studies should extend from the primary school stage to the college level and should provide continuous and liberal input of environmental concerns so that irrespective of the future career (higher education, vocation, etc.) a student decides to take up he would already have a broad but comprehensive understanding of the deep interdependence of man and his environment.

At the primary level the education should begin with the student's immediate environment using the environment itself as the study medium because that is the starting point in developing his imagination and understanding of the world. At the subsequent levels, environmental elements could perhaps reinforce already existing subjects such as nature studies, geography, civics, etc., keeping in mind the interdisciplinary nature of environmental concerns. Well designed lessons, demonstrations, open air classes, excursions, etc., should be planned in an integrated manner and courses should be preferably far removed from the large doses of "book knowledge" that has become the staple diet of present day education. Audio-visual and other aids, quizzes, debates, essay competitions etc., would be helpful for the purpose.

Some suggested course-content for different levels of the orientation education are given on page 108.

(ii) Education for specialization: at the graduate and post-graduate levels, education is largely career-oriented. Many of these courses have to do with fields of profession that have direct influence on the quality of the environment, e.g. agronomy, engineering, industrial management, town and country planning, mining, etc.

At these levels, education should provide a clear perception of the relationship of each field to the environment and the kinds of problems that could arise from the associated practices - the knowledge that may only have been generated in recent years. This obviously means that established results of research should be constantly used to modify and enhance outdated techniques and methods. In instilling the problem solving capacity into students they have to be made aware of how to make comparative assessments of environmental damage that can result from various courses of action (involved not only with the basic discipline but also with its sister disciplines) and how to make the appropriate choice best suited to the prevailing local conditions and constraints.

Besides class-lectures, emphasis may be given to project based course-work, case studies, vocational training, information seminars, etc. The possible environmental content for some courses are outlined on page 108.

(iii) Education for professional adaptation: this is to provide occupational training to in-service people who are by profession directly or indirectly involved with environmental concerns. Such people would include:

1. Professionals such as engineers, architects, settlement planners, agronomists, hydrologists, conservators, etc., who act directly upon the environment.

2. Professionals such as economists, sociologists, development planners, lawyers, administrators and other decision-makers whose functions involve them in indirect actions on the environment.

3. Teachers, community educators, science-writers, etc., who are instrumental in generating environmental awareness among people.

Such training could be imparted through suitable designed short appreciation/refresher courses, seminars, workshops, etc. The content and duration of such programmes would be determined by the nature and purpose of training.

The introduction of programmes of this kind would require some preparation in curriculum development, organizational changes, devising and testing the materials and methods, training of teachers, etc., but should begin immediately to meet the pressing requirements. Such special short programmes may be organized in a few selected educational institutions of the country where some basic environment-related studies are already well established. It would also be useful to form competent interdisciplinary training groups comprising educators, and specialists in those institutions to conduct such programmes. A few institutions, for example, are suggested below:

Core subject area	Institutions
1. Biological sciences and ecology	Madurai University; Benares Hindu University; Delhi University
2. Humanities and social sciences	Jawaharlad Nehru University; Bombay University; Gokhale Institute of Politics & Economics, Poona
3. Quantitative ecology and environmentrics	Indian Statistics Institute
4. Environmental planning and engineering	School of Planning and Architecture, Delhi; IIT, Kanpur; Jadavpur University; College of Engineering; Guindy

5.	Resource management	IIT, Delhi; Indian School of Mines, Dhanbad; Forest Research Institute, Dehradun; Soil Conservation Research Dehradun; Indian Photointerpretation Institute (Survey of India) Dehradun.

Educational needs for environmental engineers

Though engineering has many and varied interactions with the environment, present engineering education reflects this only minimally. Traditionally, the training of engineers has been designed to resolve immediate problems without much concern about the long-range consequences of their actions. As a result, short-sighted use of technology, to cure immediate ills, has often been the cause of much greater environmental problems. These considerations become most significant in the activities of those who are required to manage human settlements and quality of their environment, namely, the environmental engineers.

Environmental Health Engineering is essentially an outgrowth of sanitary engineering which primarily deals with the needs of municipal sanitation. This field has traditionally been "disease-oriented" and concerned with public water supply and waste disposal. Within the present limited areas of concern, sanitary engineering has eminently succeeded in mitigating communicable diseases, but has been unable to include work on the broader implications of environmental action and has often created new problems in the very act of solving others. These have included water pollution problems by disposal of solid wastes, pesticide pollution in eradicating disease vectors and so on. Needless to say, it was unprepared to tackle the new problems arising out of the present radical transformation of man's material environment. The first full-fledged diploma course on sanitary engineering was introduced in India in the All India Institute of Hygiene and Public Health (AIIHPH) as early as in 1938. Subsequently, a post-graduate course leading to degree of Master of Engineering (Public Health) was also introduced, in 1948, in the same Institution which was first of its kind in South East Asia.

However, to meet the changing needs of society the curriculum of sanitary engineering has of late been greatly modified to include subjects like solid waste management, industrial waste treatment, water and air pollution, environmental hygiene, rural sanitation, etc. Until recently the training was mainly confined to the undergraduate level as a part of the course on civil engineering. But now a number of Indian universities offer a master's degree and are well-equipped with research facilities in this field. A general outline of the existing courses for undergraduate and post-graduate studies (master's degree) is shown on page 109.

With the emergence of the modern concept of "environmental design and management" which essentially involves the integrated expertise of planners, architects and engineers who ultimately condition and regulate the environment of human settlements, the need for a new kind of engineering is rapidly emerging. Environmental engineering has to conern itself from now on with the protection and conservation of the human environment. It cannot be restricted only to controlling environmental nuisance and hazards from the health point of view but should also provide man with the most favourable environment possible. More emphasis on rational developmental planning as a way to improve the environment - to have one's cake and eat it too!

With these objectives in view, the education for environmental engineers should be based on "system" and "resource" approach, since ultimately it is environmental systems and resources which govern the "quality of life". An environmental engineer must visualize the human environment as a whole and not in unconnected parts. To understand the far-reaching implications of a particular development he should possess a fair knowledge about biology, ecology and related subjects in addition to technical skills.

Therefore, besides including subjects related to environmental sanitation and health, environmental engineering should also be directed to focus on problems of human settlements (both urban and rural), e. g. overpopulation, congestion, slums, urban blight, noise etc., and should also deal with environmental aspects of development projects, water resources, location of industries and cities, structuring of activities within a city, transport systems, recreational facilities, etc. The existing course needs to be sufficiently broadened to cover these areas and the training programme should involve application of modern techniques of systems analysis, organizational and management techniques, etc. Though the human environment may differ to a certain degree depending on the state of local development and other special characteristics, the basic requirements for such education would remain universal.

Some suggested course-content for post-graduate studies (master's degree) are provided on page 109.

Conclusion

Introduction of environmental education into our educational programmes is already overdue. Our institutions have to address themselves to fulfil this need. This requires the formulation of relevant policy guidelines and strategies and also development of necessary methodology and study materials. Much is expected to emerge from the forthcoming World Congress on Environmental Education. Meanwhile we must evolve an approach which will allow us on the one hand to use our present educational systems, and on the other, to develop new institutions and methods. All the while we must remember that solutions to the problems of the environment and those for the problems of development can and do go hand in hand.

This will require participation of expert educators, education planners and environmental scientists for exchange of views. In order to achieve

this, we, in India, are considering the formation of a competent advisory group comprising of representatives from universities, environmental health engineers, ecologists, planners, sociologists, engineering project mangers, systems engineers, in the Office of Environmental Planning and Co-ordination of the Department of Science and Technology. The promotion of environmental education is one of the major areas envisaged in the proposed "Environmental R&D Programme" under the "Science and Technology Plan" proposed by the Department of Science and Technology during the period 1974-1979.

Annexure I

Environmental studies for orientation - some suggested subjects

1. Primary school level

   (i) Earth Science (meaning of earth and man's record on it).
   (ii) Nature and Natural Resources.
   (iii) Need for Air, Water and Energy.
   (iv) The Process of Living.

2. Secondary school level

   (i) Outlines of Ecology.
   (ii) Human Geography (human societies and settlements).
   (iii) Resources and Wastes.
   (iv) Outlines of Environmental Conservation.
   (v) Society and the Environment.

3. Intermediate college level

   (i) Concepts of Environmental Systems Methodology and Resources Management.
   (ii) Socio-Economic and Cultural Aspects of Environmental Protection.

Annexure II

Suggested course content for environmental studies at advanced level (non-engineering courses)

Discipline	Course suggestion
1. Bio-sciences:	System Ecology; Comparative Ecology; Bio-Energetics and Bio-Chemistry; Environmental Physiology; Plant and Animal Ecology; Pollution Ecology.
2. Social sciences:	Human Ecology; Socio-Economic Development and Environment; Society, Environment and Psycho-dynamic Processes; Human Geography and Population Dynamics; Human Problems as related to Environment; Sociology of Urban and Rural Settlements; Urbanology; Environmental Legislation and Administration; Economics of Environmental Protection.
3. Geo-sciences:	Systems Ecology; Environmental Geology; Natural Resources and Environmental Conservation; Meteorology and Climatology; Geomorphology, Hydrology; Economic Resource Allocation and Utilization; Development and Environment; Population and Human Settlements.
4. Medical sciences:	Human Ecology and Environmental-Health; Ecology of Drugs; Environmental Pollution and Interrelationship of Pollutants and Pollution of Air, Soil and Water; Effects of Pollution; Noise and Radiological Health.

Discipline	Course suggestion
5. Agricultural sciences:	Systems Ecology; Agro-Ecosystems; Soil Properties and Nutrient Transfer; Soil Management and Crop Production; Ecology of Herbicides and Pesticides; Plant Protection; Plants of Environmental Significance; Land-Use; Forestry; Fish and Game Conservation.

Annexure III

Existing courses of sanitary engineering

I. Undergraduate studies for civil engineers

(i) Pre-final year (compulsory)

Sanitary engineering: Water supply and sewerage engineering - broad principles and practices.

(ii) Final year (elective group):

1. Public Health Engineering — Principles of biology, bacteriology and parasitology; Communicable diseases; Host-parasites relationships; Environmental health.

2. Advanced Sanitary Engineering — Water quality (chemistry and biology); Assessment of water quantity and quality demands; Major unit operations involved in the treatment of water and waste-water.

II. Post-graduate courses leading to master's degree

(i) Major group (all subjects compulsory):

1. Water treatment and supply - advanced
2. Waste-water engineering - advanced
3. Solid wastes and gaseous wastes engineering
4. Industrial waste treatment
5. Process system engineering

(ii) Minor group (any two subjects):

1. Sanitary bio-chemistry
2. Sanitary biology and macrobiology
3. Environmental hygiene
4. Material science
5. Higher mathematics

(iii) Ancillary group (any one subject)

1. Foundation engineering
2. Structural mechanics and concrete engineering
3. Public health administration

(iv) Special problem - course work on a selected problem

(v) Thesis - based on research on a selected topic.

Annexure IV

Suggested course for environmental engineering for post-graduate studies

(i) Background paper: Aspects of human environment as related to socio-economic development; Human geography and population dynamics; Human ecology; Natural resources - economic allocation and utilization; Quantitative ecology and concepts of environmetrics; Systems analysis.

(ii) Human settlements: Urban and countryside - location, form, structure and functional aspects; Environmental requirements in human settlements (urban and rural); Land-use planning and environmental design; Housing and working environment; Transportation and recreational services; Solid waste management; Environmental conservation.

(iii) Environmental hygiene: Environment and community health; Communicable disease and vector control; Occupational health and industrial hygiene; Environmental sanitation with special reference to air, water, soil, food quality and pollution by pesticide, noise and radioactive substances; Public health practice and social discipline.

(iv) Water quality management: Water resources - management for multiple uses; Hydrology of surface and groundwater; water quality analysis (physical, chemical and biological); assessment of quantity and quality demands; design of water and waste-water facilities; water and waste-water treatment methods; industrial water supply; industrial waste treatment; limnology and water pollution.

(v) Atmospheric environment: Meteorology and climatology; Chemistry of air pollution; Air pollutants - sources, transport phenomena; reactions and effects; Aromatic by-products of combustion; interrelationships of pollutants and air pollution; Bioassay of air pollutants; pollution control technology; economics of pollution control, noise abatement.

(vi) Environmental management: National environmental policy; Management of resources; Environmental administration; International environmental activities; Planning and development of resource system.

(vii) In addition, there should be a special problem for coach work and a thesis in partial fulfilment of the requirement for the master's degree as at present.

CONCEPTION FOR STUDY OF ENVIRONMENT CHANGING BY MAN AND TRAINING SPECIALISTS IN THE SOVIET UNION

by
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We share the concern of Unesco, MAB and other international organizations for the accelerated change of the environment by man. We understand the need to study this process and to take steps for its slowing down in order not to cause irreversible consequences. We also understand the significance and the need for training a young generation of engineers and scientists to solve this very acute and complicated problem.

But while training various specialists, writing textbooks, and planning scientific research in this field we come across the lack of a general conception. We greatly appreciate efforts of the authors of the MAB Programme as well as the ideas of other ecologists, but the environment goes beyond the biosphere! Besides cytoplasm it includes mineral substances and it also requires ecologic, socio-economic, technological and psychological analyses.

As we know, biosphere, lithosphere, hydrosphere, and atmosphere are closely connected by the interchange of matter and energy and they present an integral material system in dynamic equilibrium. It is a semi-open system having restricted relations with the earth mantle and cosmos. We call it geosphere or environment.

At present six energy factors determine this equilibirum. They are solar energy, gravity, tectonic forces, chemical energy (primarily oxidation and restoration reactions), biogenetic energy (photosynthesis, chemosynthesis, energy of oxidation and food assimilation by animals, reproduction of biomass productivity) and lastly, the sixth factor - energy of the world's industry.

The first five factors, developing conjugately according to the geological time scale for 3.5-4 billion years have formed the environment and, at last, man himself has been created who secreted from hominids as early as one billion years ago. When a socially organized man came into being a new factor: energy of the world industry emerged. This factor has developed in the historical scale of time and at present has a tendency to redouble every 15 years. Whether dynamic environmental equilibrium, which was developed during geological time, is preserved or disturbed depends on the capacity of mankind to organize production in its broad sense.

Does man adopt new conditions of the environment? Naturally, he does, but its rate, due to biological laws, lags behind the rate of environmental changes.

The scope of human activity has become gigantic. Not to exhaust you by the full list of what materials and in what quantities are discarded into the environment by the world industry but we should like to mention a few. Every year, 800 million tons of various metals and almost 60 million of (unknown in nature) synthetic materials are produced, above 300 million tons of mineral fertilizers and about 40 million tons of various toxic chemicals are scattered down in the fields, 8 milliard tons of fuel are burnt, discharging up to 20 milliard tons of carbon dioxide and over 1 milliard tons of other solid and gaseous compounds, including cancerogenic, are thrown out into the atmosphere. Efficiency of various combustions averages 33 per cent. Man uses 13 per cent of the fresh water, 600 milliard tons of which are thrown back into rivers and lakes. Due to such a degree of pollution, its neutralization requires twelvefold dilution which is not surprising, taking into account that modern industry produces 12 thousand of various chemical compounds.

By present forecast, these data will enlarge 3 to 4 times by the year 2000 in the light of modern means of control of environmental pollution.

Problems arise: for how long will natural resources last, will the climate change, will environmental equilibrium be disturbed?

As it can be seen from serious scientific sources, the climate of our planet will not change during the next 100 years and there will not be fatal, global deficiency of natural resources, though it does not exclude regional disproportions. A great concern is caused by a possibility of disturbance of chemical environmental equilibrium due to imperfect technology which does not match the power of modern industry.

Disturbance of chemical environmental equilibrium occurs not only because of heavy losses while extracting and treating raw materials but also as a result of scattering material during use. There are no eternal goods. Technogenic entry of chemical elements and their compounds into the environment which are widely used in industry and private life, exceeds 10-100 times their natural entry (volcanic processes and rock weathering).

For example, almost half of 650 million tons of reduced iron are lost during the first year due to treating, mechanically working, and corrosion. One-third part of the chemical minerals extracted is lost in treatment and transportation. If protective measures are not taken, considering the growth of industrial production, then the content of iron oxides in soil and surface waters will be doubled, lead and zinc compounds will increase by 10 times; mercury, cadmium, and strontium - by 100 times etc.

And here we come to the deadline. We have surprisingly little knowledge of what changes chemical elements and compounds might undergo as they are plentifully diffused in the environment. For how long have they been conserved and what will they come to? What is the capacity of the environment to absorb these pollutants? What is the limit beyond which a catastrophe can follow? In a phrase, the problem of circulation of matter and energy in the environment is to our regret not worked out. In case where knowledge of natural circulation and the quantity of additional growth of industry is available, it should be possible to forecast environmental changes.

We calculated that all over the world in the process of extraction, transportation, treatment and utilization almost 50 million tons of oil and its products are lost yearly; this amounts to 2 per cent of the annual extraction. About 15 million tons of the oil and its products mentioned above go into the ocean, up to 23 million tons of hydrocarbon, as vapour and gas, enter the atmosphere and 11 million tons of heavy oil products remain on the land. At a temperature of 20°C oil is oxidized within a fortnight, at 15°C the process of oxidation takes half a month, and at a temperature of 5°C half a year. In arctic waters oil remains for years. For instance, in the Chedobakto Harbour, Nova Scotia, Canada, due to the cold Labrador current, an oil slick has remained for almost 4 years since the catastrophe of the "Arrow" tanker in 1970 when 16 thousand tons of oil were poured out.

One-third of young bionts perish under long effects of oil. Oysters taken in waters polluted by oil have up to 30 micrograms of benz(a)pyren, 100-200 micrograms of chriyzen, more than 300 micrograms of flouranten and other cancerogenic hydrocarbons per 5 Kg of shelled oysters. Mineralization of the oil poured on the earth crust occurs at the same rate too, but what happens to its components in the atmosphere. Unfortunately we do not yet know.

At present the demand for oil increases by 8 per cent and extraction by 5 per cent a year. At such a growth of oil usage and its present losses, the latter may increase twice as much by 1985, and it may create a critical situation for survival of a number of biocenoises and man himself. Therefore the development of non-polluting sources (solar energy and controlled thermo-nuclear syntheses) and a renouncement of the burning of organic fuel have become a vital condition for survival.

Contamination is dangerous for man, animals, and plants because organisms are capable of accumulating elements and compounds within themselves, which do not participate in metabolism. The concentration of lead compounds, pesticide DDT and other toxic substances in plants, and in the body of animals and man exceeds dozens of times their content in soil, natural waters and air. This toxic matter is found in the mother's milk which is passed on to the new generation. Due to general circulation of the atmosphere and water on the earth, contamination has taken a global character. A lot of toxic substances are found in samples of ice from Greenland and in the Antarctic where certainly nobody scattered them. For the past 20 years the concentration of tetra-ethyl-lead in ocean waters has increased tenfold.

Modern means of pollution control, including biological, enable one to catch 70 to 80 per cent of pollutants in the laboratory. In practice not more than 25 per cent of pollutants are caught on a world-wide scale (65 per cent in the Soviet Union, about 50 per cent in the United States, less than 10 per cent in the developing countries). The means of pollution control are very expensive yet (10 to 40 per cent of the overall cost of enterprises) and they are not reliable in operation. The outstanding American economist and ecologist Barry Commoner has presented a socio-economic aspect of this problem. In his opinion, the present conflict between man and nature is caused by the uncoordination of private enterprises still dominating on the earth with vital social values, such as the environment has for mankind.

An analysis of concentrations of industrial wastes shows that the atmosphere, soil, and river waters in the Soviet Union are in average three times as clean as in the United States, Federal Republic of Germany and Japan. It is sufficient to compare the air in Moscow and Tokyo or the water of Dnieper and Rhine or Volga and Mississipi to see the difference. It is one of the advantages of socialism.

Recently the expenditures on restoration and protection of the environment in the Soviet Union exceeded 2.5 per cent of the national income, that is about 8 milliard roubles a year. In the United States, they amount to 1 per cent of the national income or 3.6 million dollars. The report of the United States Council on Environmental Quality (March 1972) states that the equipping of 12,000 leading enterprises by pollution control facilities would take 32 milliard dollars spent over 5 years, and this in its turn would increase the cost of production by 2 per cent. To equip all the industrial enterprises with cleaning facilities and to recultivate injured nature, it would take 10 times as much, and simultaneously the production cost will grow. These figures are likely to give some notion to an American that pollution of the environment is an inevitable phenomenon. Is it really the case? Naturally, the need for environmental expenditures on protection, reproduction and reconstruction of the environment in a number of countries amount to and sometimes exceed national income. The time when man, like a child, was totally provided by nature and its resources has passed. He polluted the environment, wasted its resources and nature as the mother coped

successfully with neturalization of wastes in order to maintain equilibrium of matter and energy cycle to a certain extent. At present the rate of pollution has reached, and in some cases exceeded, the rates of their natural decay. Hence, we observe such a great degree of pollution and degradation of the environment that it needs large funds for its recultivation and reconstruction.

What are the ways to overcome this crisis without lowering the production growth and living standards of a numerically increasing population.

To overcome this crisis in the interrelations between man and environment over the whole planet with countries of different socio-economic structures there is no other sensible way out but to put an end to the arms race. The restriction of arms, and particularly strategic disarmament, will make it possible to save annually, at least, 125 milliard dollars which represent only half of all military expenditures throughout the world, and to use them for raising the economy of developing countries, for the control of population growth, for the improvement of cleansing facilities, for the promotion of search for new non-polluting sources of energy, and as a strategic task to transform gradually industry into recycling, "dry" technology and an industry without by-products.

These are the main conceptions about the interrelation of man and the environment of which we inform our students. The process of training and teaching the specialists, including various engineers: chemists, metallurgists, etc.; in the fundamentals of environment protection has three trends in the Soviet Higher Schools.

I. The creation of special departments "Protection of Nature" at biological and geographical faculties. They are few in number.. Such departments were organized in Kazan and Tomsk Universities, and similar departments were opened in Irkutsk and Rostov Universities this year. Specialist-ecologists trained at these departments work mainly at natural reserves and at some planning organizations. However, experience shows that if it is easy to train a specialist to work at a natural reserve (but they are not in great demand) it is extremely difficult to train such an ecologist who will be experienced in numerous branches of modern industry.

II. Thus, there exists another way: it is obligatory to deliver lectures on the fundamentals of environmehtal protection to future engineers at universities, polytechnical, technological and other institutes whose graduates will deal with the utilization of natural resources, or with exploitation of territory and water areas.

Such courses under different names are included now in educational programmes of almost all universities and institutes. In particular at the Moscow State University at the Faculty of Geography, Professor A. M. Riabchikov delivers a course, which takes 70 hours, to all the students. It is called "Changing of Environment by Industry" and Professor T. V. Zvonkova delivers lectures on "Bases of Geographical Forecast" at planetary and regional aspects.

A course entitled "Economic Bases of Rational Use of Natural Resources and Environmental Protection" is delivered at the Economic Faculty of the Moscow State University. At some faculties the course "Interaction of Man and Biosphere" is given. As you know, the matter is not in the name but in the essence. The course of lectures is interesting and useful only when the professor solves problems together with his students. With this purpose, scientific laboratories on this topic were organized in a number of Soviet universities and institutes. A special scientific council co-ordinate scientific subjects, and it can finance them.

III. However, no matter how important are the courses on environmental protection, rational use of natural resources, and their economic evaluation, this training is not sufficient for specialists employed in modern industry. Thus, the system of Soviet higher education has a third level of training specialists by means of special courses and seminars. According to the solution from the Higher Education Ministry College every professor delivering special courses, for example, on chemical technology, metallurgy, mining, agriculture, use of water etc., must pierce them with ideas and methods of environmental protection. Some lecturers consider these problems in a special section of the course. Architects think of how to arrange a complex of constructions on a definite landscape, to retain its natural appearance.

As modern science and engineering have been differentiated a great deal, a rigid scheme to present these problems does not and cannot exist. A great many methods of using natural resources and technological processes define a lot of viewpoints on environmental protection. Under these conditions it is especially important to work out the basis of a general conception of this extremely complicated problem.

A lot has been done and is being done in the field of environmental protection, and reconstruction as well, in the field of education in the Soviet Union. This problem has become State policy. Nevertheless, we are far from an idealization of our achievements. A great deal should be done both in scientific and practical aspects. In this connexion we think that the discussion of the problems of education and training will be useful and of great interest. It is very important to define basic conceptions of these problems in order to relay race to new generation.

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